A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfillment of the

Degree of Master of Science

THE IMPACT OF BIOFUEL ON FOOD CRISIS

CASE STUDY: TROPICAL RAIN FOREST AND TROPICAL GRASS LAND IN CAMEROON

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CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THESIS submitted by:

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Case Study Tropical Rain Forest and Tropical Grass Land in Cameroon

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From April 2008, many developing countries including Cameroon were victims of the shortage public food protest. In some cases the food is used for biofuel or land is used for biofuel feedstocks second generation. *Jatropha curcas* tends to be promising as the second generation feedstock: can grow in arid and humid regions. Nevertheless, cultivating it blindly usually has impacts on food in Cameroon and anywhere.

By integrated assessment, it is possible to manage *J. curcas* cultivation in Cameroon through a characterization of tropical rain forest and tropical grass land differentiating small and large scale system. The questionnaires coupled with interviews helped to understand the interaction of all stakeholders involved in biofuel production and food crisis through land issue. The maps obtained through GPS position records help to understand the differences and impacts of these systems of cultivation. The policy helping the system was assessed.

It is found that more than 90% of rice in Cameroon is imported whereas soils appropriate for its cultivation are used for *J. curcas* in large scale. It is demonstrated that small scale cultivation do not have impacts on lands and food crisis thus is profitable but the large scale has direct impact on fertile lands, food crisis and deforestation.

The method retained is to include *J. curcas* cultivation in MINADER program. That ministry should set out arid zone for biofuel and at the level of method used, ameliorate seeds quality. Avoiding GMOs in the system, CEMAC, WTO, African Union should set a complementary policy.

Keywords: Biofuel, *Jatropha curcas*, feedstock, policy, rain forest, grass land, second Generation biofuel, deforestation.

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List of Abbreviations

ACDIC: Association for Collective Consumer Interest Defend

AU: African Union

CEMAC: Central African Economic and Monetary Community

CO: Carbon Oxide

DPA: Douala port Authority

ETBE: Ethyl-Tertiary-Buthyl-Ether

EU: European Union

GHG: Green House Gas

FAO: Agricultural Organization fund

GPS: Global Positioning System

GMO: Genetically Modified Organism

IEA: International Atomic Energy

INS: Institute of National Statistic

IRAD: Institute of Agricultural Research for Development

LIFDCs: Low-income Deficit Countries

MINADER: Ministry of Agriculture and Rural Development

NGO: None Governmental Organisation

NOx: Nitrous Oxides

OECD: Organisation for Economic Co-operation and Development

SENEMA: Former rice and maize mechanized agriculture international Company in Nkoteng region.

SOSUCAM: Sugar Cane Company in Cameroon

UN: United Nations

WTO: World Trade Organisation

CHAPTER I: INTRODUCTION

1- INTRODUCTION

Between February and May 2008, protests over food prices and food shortages in more than 30 developing countries captured world media attention. These countries include Pakistan, Ivory coast (1^{st} April 2008), Senegal, Haiti (8 April 2008), Bolivia, Philippine, Egypt, Morocco, Mauritania, Senegal, Egypt, Burkina Faso, Ethiopia, Madagascar, Pakistan, Thailand, Philippines, Indonesia and of course Cameroon (21^{st} February 2008). Many authors examined the causes of this food crisis. According to the United Nations (2007), liquid biofuels have a relationship to food security and food crisis.

The most important thing is the availability of food, because people are using food for biofuel or use potential energy appropriate for food to fuel cars. The stability which refers to the time dimension for securing food could affect biofuel due to petroleum price volatility. Also important is the competition between drinking water supply to people and water to produce biofuel.

Jefferson *et al.* (2008) have demonstrated how some biofuel feedstocks such as *Jatropha curcas* can grow in semi-arid regions. On the contrary, these plants grow in humid zones (proper for food cultivation) in Cameroon rather than in the semi-arid part of the country, North Cameroon. Simultaneously, some palm oil plantation companies are processing oil for export to other countries for biofuel purposes. As a result of this, there is low supply of such products and they sometimes disappear from local markets, while palm oil is usually use at least 4 days per week for the preparation of food.

The consequences are very unimaginable for the whole population. Even if Cameroon is usually called ‘’ Africa in miniature’’; this name merely describes Cameroon's climatic diversity when compared to other African countries. From the north to the south, we have semi-arid climate which varies to equatorial and humid climates in the Centre and Southern region of Cameroon. Cameroon's population needs more food which can be justified by the facts below.

According to FAO (2008), Cameroon is classified as a low-income food-deficit country. FAO (2008) further estimated deficit of cereals in 2007 and 2008. The total amount of cereals aid in 2007 stood at 630 thousands tons and 51.5 thousand tonnes in 2008. In the same study, it is demonstrated that the aid for food in Cameroon was 0.5 thousand tons, less than 1.6 thousand tons in 2007. This means that the local and national systems depend on international food trade.

This means that the availability of cereals in international market conditioned the price and controlled the demand and supply curve of cereals stocks.

The FAO (2008) report predicted increases in the price of cereals from 2007 to 2008. The growth of cereal utilization was 2 % in the past decade, but it increased significantly to 3 %. Most of the anticipated rise in quantity is expected in developing countries like Cameroon and China due to their higher intake of more value-added food, especially in China (FAO 2008). This can be justified by grain consumption by animals, for the purpose of protein production. Chicken feed mainly constitutes cereals, and we need more cereals for animal feeding to produce proteins as highlighted by FAO (2008).

Furthermore, these are areas suitable for maize production in most tropical zones, used mainly for biofuel production. The United Nations (2006) maintains that leading feedstock for biofuel is corn for the United States and cereals for the European Union. They are also contributing as cereal supply donors or sellers to Central Africa. This can cause the competition between maize for biofuel and maize for food as basic human needs. In 2007/2008 United States used 37 percent of cereals for ethanol production higher than the percentage used in 2006/07. The idea of grapping land by biofuel feedstocks cultivation is also interesting to be considered.

Following this further, Agroils and Venture Energy Ltd Cameroon are two companies that managed and earned in 2006 a concession of 20,100 hectares midway between Douala and Yaounde, the city of Douala with more than 2 million inhabitants and Yaounde with more than 1.5 million people (INS 2002). This cultivation occurs by using appropriate agricultural lands suitable for food production specifically for Douala and Yaounde populations. One of the main issues is the potential eutrophication of some rivers like Sanaga useful for irrigation and electricity production, due to the type of mono cropping. With this single river producing more than 70 % of hydroelectricity power in Cameroon. This river is the only one that is not salty[1] in the region, therefore suitable for agriculture. Agroil and other biofuel companies' leaders have as objective large scale production of biofuel feedstock by taking or reducing fertile land suitable for farmer food production.

According to the United Nations (2007) the more involved farmers are in the production, processing, and use of biofuels, the more likely they are to share the benefits. But how many hectares will remain for farmers? Those villagers that stay outside of this system

[1] This region is far from Douala estuary and Sanaga is a river flowing to the Atlantic Ocean (salty water); this river is not yet too much polluted by fertilizers to become salty.

are encouraged to cultivate biofuel feedstock for companies in different regions. They do so to the detriment of food production. Many of the crops currently used as biofuel feedstock require high-agricultural land and significant input fertilizer, pesticides and water (United Nations 2007). This means that, they are diverting land and other productive resources away from food crops.

But, if leguminous nitrogen fixing biofuel crops feedstocks can be rotated with cereals, the overall productivity may be enhanced.

Regarding the agricultural policy in Cameroon, it is very uncertain. The government of Cameroon through MINADER and its representative does not have a "social biofuel program", focused on small rural cooperatives, so as to alleviate poverty (United Nation 2007). Worldwatch Institute (2006) proposed that farmers should share the ownership throughout the production chain so as to guaranty their benefits. Many NGOs and other organisations in Cameroon are either against or for the agricultural or biofuel policy of the government, international organisations or regional organisations. For instance, the Association for the protection of Consumer Interest (ACDIC) is against the budget of the agricultural ministry (MINADER) which is only 1.45 % amount of the whole national budget. World Trade Organisations' policy came out also and did not state the proper rules for biofuels trade.

1-1 IMPORTANCE OF STUDY

First and second generation biofuels distinguished by their feedstock. In fact, the various biomass feedstocks used for biofuels production can be grouped into two basic categories: ''first generation'' feedstocks are important for their sugar production, their oil or starch that can be converted into liquid fuels through usual conventional technology.

The ''second generation'' or ''next generation'' feedstocks are harvesting for their entire biomass and their fibers can be converted into liquid fuel through advanced (thermo-chemical, mechanical, biochemical) or sophisticated[2] processes (Worldwatch Institute 2006). The important consideration here is the alternative of using first generation feedstocks as food or process to obtain liquid fuels whereas second generation feedstocks have no alternative to be used as food.

Besides this, first and second generation feedstocks are planted on agricultural lands which can of course be used for food production such as cereals, tubers and orchards. This also means that the integrated cultivation of each type of feedstock with different other potential inputs for agricultural activity will define the shortages of food supply and demand.

Many parameters can predict the threat of the social or economic problems that biofuel feedstock can generate. The concentration of the population and the quality of land used and land tenure is very important. The system of feedstock cultivation is also more important. Large scale cultivation requires more land, while sustainable cultivation of feedstocks requires small scale for decentralized system (United Nation 2007). Both will however produce different economic effects in terms of food demand and supply.

Additionally, second generation biofuel feedstocks can cause many problems for the environment. The degradation of the environment is very clear in Littoral and tropical rain forest regions of Cameroon (Centre region) where large scale biofuels are cultivated and the Northwest region in Cameroon, where small scale second generation are cultivated.

[2] Biofuel first generation feedstock has limited technology process and some particular disadvantages too.

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The importance of this study involved the fact that many nations invest in different types of biofuel feedstocks cultivation without any recognized global, regional, national to local planning. Furthermore, the sustainability of food security is an important issue when producing energy from biomass in rich or poor countries (United Nations 2007). The sustainable use of biomass for fuel will not have significant impacts on food supply for human being or any negative effect for the population.

1-2 Aim of Study

The aim of this study is to identify weather; one of the driving forces behind food crisis in Cameroon is from biofuel production. Outcome of this research is to propose concrete solutions to the problem of food crisis and how to mitigate the impacts of biofuel production.

1-3 Hypothesis

The hypothesis is to support the research questions. Industrial plantations for biofuel feedstocks need enough land to reach their production targets. This hypothesis can be considered at this moment: I would like to investigate whether there is a significant relationship between biofuel second generation feedstocks (especially *J. curcas*) production and the food crisis in Cameroon. In fact, I will be able to answer these questions: What is the influence of large-scale and small scale Jatropha's plantations on food security in Cameroon and Central Africa region? Land use is an important issue nowadays for *J. curcas* feedstocks in Cameroon?. How do various stakeholders such as agribusiness, NGOs, local communities and government perceived the interaction of biofuel development and the food crisis in the specific case of Cameroon? What types of agricultural and bio-energy policies and programs could be designed to move towards both food and energy security?

1-4 Scope and Limitations of the study

This study is done in Cameroon. The scope of this study is limited specifically to two different agricultural regions. The first region is around Douala (littoral region), with a population of more than 2 million inhabitants (INS 2002), Yaounde with more than 1.5 million inhabitants and also the Northwest with a high population density. I have localized the study in these regions; the tropical grass land (Northwest of Cameroon) and tropical rain forest (Centre region, Cameroon) constituted of zones of permanent crops and arable land with percentage density of 30-40 while the northwest region has a percentage intensity of permanent crops and arable land of more than 60 % (FAO 2009a). The focus on the fields is more on present second generation feedstock (*Jatropha spp*), because of their different types of cultivation system (large scale in littoral and decentralized small scale in northwest). These localities are therefore selected for the diversity (*J. curcas* and *saccharum spp*) of their biofuel feedstocks, advanced of poverty of the local people and production patterns of biofuel. The estimation of cost is based only on feedstock. From these descriptions, it was difficult to have access to some localities in a short time because of lack of roads; I walked some time by foot (50 Km) to visit some localities.

CHAPTER II: LITTERATURE REVIEW

2- Biofuel and sustainability

For the purpose of improving energy security, to significantly decrease or completely eliminate greenhouse gas emissions, governments select and promote alternatives to fossils or conventional fuels which is currently dominating the transportation sector.

It is very pertinent to note that several types of fuels have emerged: especially fuel cells or photovoltaic, biogas and biofuels. These different new energies sources have significant share in the fuel market especially when they are utilized worldwide. Nowadays, biofuel is more attractive due to the lower contained pollutant and recommended by many environmental specialists; besides that, the debates still remain on sustainable large scale production. Biofuels have their potential to "jump" or breakdown the traditional barriers of alternative fuels. Because of their liquid state, they can be used for many engines: stationary or movable engines.

2-1 Definition of biofuel

According to IEA (2004), biofuels are:

"Either in liquid form such as fuel ethanol or biodiesel, or gaseous form such as biogas or hydrogen, biofuels are simply transportation fuels derived from biological (eg. Agriculture) sources".

Their source varies: cereals, sugar crops and grains, other starch such as maize and cassava starches that can be easily fermented to produce ethanol. This ethanol can be used directly in engines as pure or blending component in gasoline; ethanol can also be converted to ethyl-tertiary-buthyl-ether (ETBE) before use.

Other important materials are cellulosic (which includes grasses), various agricultural waste products, trees, solid wastes from urban areas and processing facilities from wood, which can be converted into alcohol.

Oil-seeds crops such as soya bean, sunflower and rapeseed are usually transform into methyl ester, which is liquid and can be blended with fossil fuel diesel.

Organic waste materials such as waste oil can be converted into biodiesel (oil from restaurant); biogas can be produced from organic household waste and animal manure; transformed waste can be burnt into pure diesel or blended with fossil diesel:

Finally, these organic waste materials from agriculture and forestry can be transformed into ethanol. The most important thing here is that the available quantity can vary depending on the region, but raw materials can generally be of low cost or even free for some types (IEA 2004).

2-2 Advantages of using biofuels: why so much interest in biofuels?

Biofuel is primarily considered as an alternative to conventional fuels. IEA (2004) pointed out that recent events in the world is to find out a way to achieve a level of energy security and will definitely reduce the oil import dependency, thus, should be considered at the top of IEA countries agenda such as renewable energy for heating and cooling (IEA 2007). IEA perceives global climate change as a form of critical environmental change and energy policy issues. These are rising pro rata to the greenhouse gas emitted by combustion of fossil fuels that is imposing high rate of risk for our planet. Traviss (2008) *and* IEA (2004) have pointed out that biofuels can offer partial solutions to some of these problems by displacing fossil fuels and reducing emission of green house gas (GHG) in fuel consumed per litre.

Estimating the net impact along the biomass production through the transformation to end consumption is a complex issue (IEA 2004). It has been noted that from different varieties of biofuel feedstocks, the great question is how much carbon dioxide gas (CO_2) and other emission of GHG are released in our environment during the production to have liquid fuel end use.

The table 2.1 below shows how one example of biofuel (biodiesel soya bean based) is very important in the reduction of GHG; the reduction of different pollutants is calculated or differentiated in two cases: B100 (blend at 100%) or B20 (blend at 20%). From the table, we can see that using pure biodiesel, the reduction of green house gas is very significant but it increases NO_x up to +12%.

Table 2.1: Biodiesel soya bean based reductions in regulated tailpipe emissions compared to 100% Petroleum diesel (Traviss 2008).

POLLUTANT	B100	B20
Hydrocarbons	-80-90%	-21%
CO	-40%	-11%
Particulate Matter	-30-50%	-10%
NO_x	+12%	+2%

Furthermore, Traviss (2008) let us to understand this relationship which is that, measuring per gallon or litre such as basis, soya bean to base biodiesel can provide up to 69% more energy efficiency than the standard fossil fuel energy that is going into making it available. This study also makes clear that soya bean based biodiesel can provide up to 93% more energy compared to the fossil fuel energy that is invested in its production.

Another benefit of using biofuel is to save some money by blending the conventional fuel to run engines. It is usually important to note that modification of engines is not needed or is significantly needed; that is why Traviss (2008) expresses the technical modification benefit of diesel engine which is necessary before using biodiesel.

By blending fossil fuel with biofuel, it is possible to save huge amounts of money per year (Traviss 2005). Nevertheless, EIA (2008) has claims that biofuels are about 1.5 times more expensive than oil or fossil fuel.

It is still interesting today to realize that biofuels are economical, offer operational and political benefits. They are also used within households. The rapid rise of biofuel industries has resulted directly in new jobs creation, especially surplus revenue for farmers cultivating soya bean in USA, as has been shown by Pahl (2005).

Biofuel as a natural oil is biodegradable and less toxic, can have high properties for the lubrication of engines compared to diesel fuel or fossil fuel. The slight solvent effect of biofuel facilitates the cleaning out of engines. The lubrication and self cleaning extend automatically increase the life span of our engines. Traviss (2008) also showed that self lubrication implies no use of sulfur in fuel.

Since biofuel is produced from plants, those plants can continuously be grown and capture carbon in the atmosphere. Biofuel based on some selected feedstocks can significantly reduce the footprint. This could also depend on land type and management, agricultural input (from soil preparation to post harvest technology management) and marketing approach. The reduction of footprint can also cause less negative effects on the environment and on human health. That is why Traviss (2008) brought out verification to show the 10% decrease of particles (< 10 µm) and net increase of NOx when blending fuel at B20 (20%).

2-3 Increase food demand

Nowadays, because of the positive impacts of biofuels, many environmentalists or business makers are concentrating their investments in the production of biofuel feedstock production and in the plant processing of biofuels.

Biofuel versus food is an actual discussion topic in the world and many other questions around this topic are usually highlighted. If somebody asks us this question: "can we in general grow enough biofuel?"; the answer is not easy, but should probably be no (Traviss 2008).

It will be very interesting if I address the issue of global hunger by highlighting the growth of hunger in sub-saharan Africa, which includes Cameroon. According to United Nations (2007) with reference to data from FAO for 2001-2003 years, 854 million peoples are undernourished in the world. Among these people, 820 million come from developing countries with 206 million in sub-saharan Africa. The report assesses that:

''hunger claims up to 25,000 lives every day, two thirds of them children under the age of five, and it is currently the leading threat to global health, killing more people than AIDS, malaria and tuberculosis combined…. Impact of bio-energy on food security should be highlighted'' (United Nation 2007).

If we take into account the fact that 3 billion people are malnourished based on a decrease in nutrients such as protein, vital minerals, vitamins and calories in their diets (Pimentel and Pimentel 2008). These basic needs can be found in livestock or animal production; Pimentel and Pimentel (2008) showed that 40 % of grains are used to feed animals (livestock) instead of direct consumption by humans while grain provide 80% of world food supply.

FAO (2009$_b$), cited Cameroon in the low-income deficit countries (LIFDCs). This leads me to highlight the situation of bioenergy on food security in developing, LIFDCS and least developed countries. Most food insecurity occurs in the LIFDCs where people depend on primary staple foods imports and prioritize primary tropical exportation commodities (United Nations 2007). Indeed, because hunger is severe in the developing world, many authors have shown how this is mostly concentrated in rural area. If no sustainable progress is made towards food security by paying attention to rural development and agriculture, the situation could become catastrophic.

The figure 2.1 below shows the relationship between the populations in undernourished regions with the agricultural employment. This proves the vulnerability of rural population having traditional agriculture as their principal source of revenue or employment. This vulnerability will depend on the subsistence consideration of their agriculture and the export of agricultural products; nevertheless, the consideration of the vulnerability is very important to take into account in Africa: because large population undernourished in rural area relies usually on a piece of land less than 1 hectare/year.

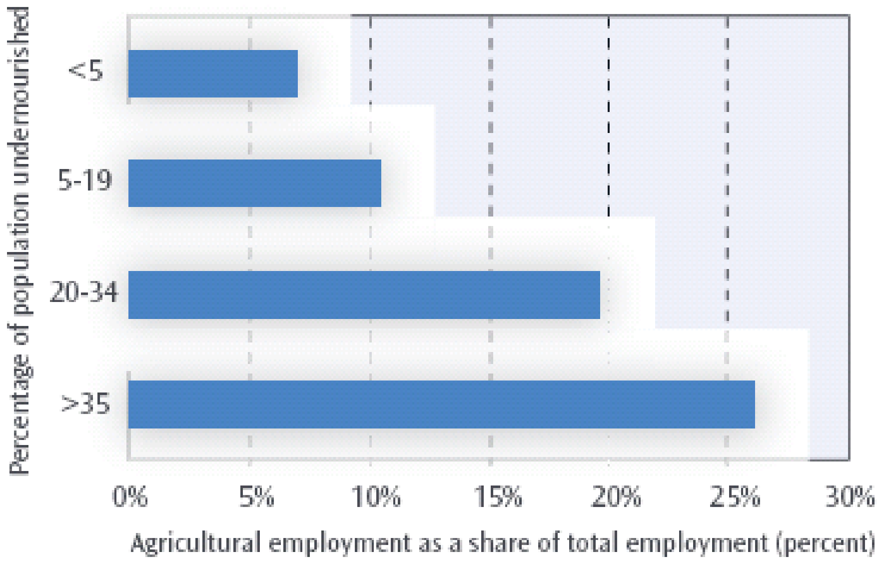

Figure 2.1: Agricultural employment and undernourishment (2001-2003): Source: United Nations (2007)

Approximately 30 % of world grain production is currently used as animal feed (especially poultry). The development of biofuel will likely lead to change in the diet of people (United Nations 2007; Worldwatch Institut 2006); for instance if cereals are used for biofuel, farmers will switch for instance to beef or other foods that are not available or cannot be cultivated two times per year such as cereals in many regions . People afford calories by consuming more meat; this is the cause of food insecurity since three decades.

However, the high demand for food calls for high input resources, especially additional lands and water to grow crops for direct human, animal feed and for biofuel feedstocks. That is why biofuel feedstocks production have significant water footprint (Dominguez-Faus *et al.* 2009). We remember that, access to water is one major problem in Africa. To illustrate this, UK Parliament POST (2002) showed how the proportion of people in Africa with water stress will increase significantly from 34 % in 1994 to 63 % in 2025.

2-4 Reduction of Food Availability by Biofuels

Diverting land availability and some other resources for food production for the purposes of biofuel (fertile land, water, and manpower) should continue to stress the agricultural system or food cropping system. As demonstrated in Table 2.2**,** different feedstocks need land and more or less, all other agricultural inputs to have good products. However, *Jatropha curcas* L. needs less conditions or more flexible conditions for growth.

This is the reason that pushes many people today to focus on second generation Jatropha feedstocks (Mali-Folkecenter. 2004); since Jatropha's agro ecologic zone is only possible in the tropical and subtropical areas of developing countries. Developing countries have become safe having meeting for all Jatrofa's investors in the world. The large scale production is usually done by investors principally from developed world, and from developing world as I will illustrate later with the case Agroil in Cameroon.

As a result, *Jatropha curcas* is considered as a multipurpose plant that can be used for soil protection, land reclamation, hedge and commercial crop (Openshaw 2000).There is high desire among many governments in growing *J. curcas* as feedstock for biodiesel (Achten *et al.* 2008). Some governments do not have plans to gather or to establish a national Policy for *J. curcas* cultivation. In addition, the cultivation of *Jatropha curcas* appears as an excellent adaptation to semi-arid lands (Jefferson *et al.* 2008) and tends to boost Brazil's sustainable agriculture significantly. Jefferson *et al*. (2008) further pointed out that agricultural research is still needed in seed selection of *J. curcas* to improve production and their oil seed's properties. As a result of the present market

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potential of *Jatropha curcas,* Openshaw (2000) requested to improve its growth and management.

Table 2.2 makes clear the different types of biofuel feedstocks. Furthermore, this table shows the characteristics of each type such as soil conditions, water needed, nutrients needed in soil and favorable climatic conditions. It is clear that cereals, maize, oil palm and *J. curcas* do not need more input compared to sugar cane, potato, sorghum and rice. That is why more interest has been given to maize, cereals in USA. Because of indirect or ''blind'' competition between *J. curcas* and food, coupled with the fact that it is tolerant with climate and water needed, people nowadays shift to its cultivation. The productivity of these feedstocks described in Table 2.2 below is an important issue of discussion nowadays. That is why the productivity of some feedstock will be done in Table 2.4. That is why the choice of any biodiesel feedstock will also depend on energy yield per unit area and end use efficiency.

Table 2.2: Assessment of different biofuel feedstocks (United Nation 2007)

CROP TYPE	SOIL	WATER	NUTRIENTS	CLIMATE
Cereal	less disruption of soil; very constant yield; humus balance is negatively influenced by annual removal of straw	–	medium	moderate
Hemp	deep soil with good water supply, pH balance between 6 and 7	some moisture the entire season	moderate, no pesticide needed	varied environmental conditions, preferably warmer climates
Jatropha	undemanding, does not require tillage	can be cultivated under both irrigated and rain-fed conditions	adapted to low fertility sites and alkaline soils, but better yield can be achieved if fertilisers are used	Tropical and subtropical but also arid and semiarid.
Maize	soil should be well-aerated and well-drained	efficient user of water	require high fertility and should be maintained continuously	temperate to tropic conditions
Miscanthus	good water supply, brown soils with high humus percentage, optimum pH between 5.5 and 7.5	crucial during the main growing seasons	low	adapted to warmer climates but fairly cold-tolerant
Oil Palm	good drainage; pH between 4 and 7; soil flat, rich, and deep	even distribution of rainfall between 1,800 and 5,000 throughout the year	low	tropical and subtropical climate with temperature requirement of 25–32°C
Poplar	deep, moist soil, medium texture, and high flood tolerance	high; irrigation may be needed	high	arctic to temperate
Potato	deep, well-drained, friable, well-aerated, porous, pH between 5 and 6	high; irrigation required	high fertiliser demand	optimum temperature of 18–20°C
Rapeseed	mild, deep loamy, medium texture, well-drained	600 mm minimum yearly precipitation.	similar to wheat	sensitive to high temperatures, grow best between 15 and 20°C
Rice	needs permeable layer and good drainage	very high, grown in flooded fields	relatively high input of fertilisers, very intensive systems	constant temperatures in tropical areas, optimum around 30°C
Sorghum	light-to-medium textured soils, well-aerated, well-drained, and relatively tolerant to short periods of water logging	shows a high degree of flexibility towards depth and frequency of water supply because of drought resistance characteristics	very high nitrogen feeding crop	optimum temperatures for high producing varieties are over 25°C
Soybean	moist alluvial soils with good organic content, high water capacity, good structure, loose soil	high	optimum soil pH of 6 to 6.5	tropical, subtropical, and temperate climates
Sugarbeet	medium-to-slightly heavy texture, well-drained, tolerant to salinity	moderate, in the range of 550 to 750 mm/growing period	adequate nitrogen is required to ensure early maximum vegetative growth, high fertiliser demand	variety of temperate climates
Sugarcane	does not require a special soil type, but preferably well-aerated with a total available water content of 15 percent or more	high and evenly distributed through the growing season.	high nitrogen and potassium needs but at maturity, the nitrogen content of the soil must be as low as possible for a good sugar recovery	tropical or subtropical climate
Sunflower	grown under rain-fed conditions on a wide range of soils	varies from 600 to 1,000 mm, depending on climate and length of total growing period	moderate	climates ranging from arid under irrigation to temperate under rain-fed conditions
Switchgrass	ranging from prairies to arid or marsh	drought-resistant and very-efficient water use	low	warm-season plant
Wheat	medium textures	high	high	temperate climates, in the sub-tropics with winter rainfall, in the tropics near the equator, in the highlands with altitudes of more than 1,500 m, and in the tropics away from the Equator where the rainy season is long and where the crop is grown as a winter crop.
Willow	sandy, clay, and silt loams	substantial quantities of water	significant nutrient uptake	can tolerate very low temperatures in winter, but frost in late spring or early autumn will damage the top shoots.

Because favorable climatic condition is that of the tropics, it is logical that in poor countries in sub-Saharan region, some particular industrial states' investors that increase the purchase of agricultural land in the South. Sometimes this leads to dramatic consequences for local populations.

2-5 Agricultural System in Cameroon

The agricultural system in Africa is very different compared to the one in the developed world. On Figure 2.1, it was demonstrated that in developing countries such in Sub-Saharan Africa, the part of undernourished population (especially farmers) share at least 35 % of total employment. In general case in developing countries in Africa, more than half of total population in some countries usually relies on traditional farming. One of the interesting factors here is the size of their land usually less than 1 hectare/year. The interesting factor here The Cameroon's Ministry of Agriculture and Rural Development (MINADER) has as priority no agricultural policy; no care for agricultural system for the future. Energy policy requires various strategies, a framework for a sustainable economy, a grant limited in time, multi-sectoral integration: agriculture, energy, forest and environment.

Central African Monetary and Economic Community (1994), in article 32 laid down regulations in the mutual information system involving of its member states so as to coordinate their agricultural, pastoral and fisheries system. There is no law for the regulation and enforcement of biofuel production.

Furthermore, more than 48 % of Cameroonians live in rural areas (FAO 2009_a). This exerts pressure on the land that supposed to be divided in pieces for each farmer's family. The farming land management system is not reliable for long term mechanization, or not reliable for large scale sustainable farming when compared to the Jatropha's investor ideas. The evolution of land use and agricultural policy in Cameroon is peculiar.

2-5-1 Land use history in tropical rain forest of Cameroon

The tropical rain forest includes Center region as found in figure 3.1. In fact, it is a part of Congo basin region (second largest forest region after Amazonia). In this region, one Chinese rice company was in place at Nkoteng, created before 1980. This company was farming on area of more than 1000 hectares. It is true that this region is a tropical rain forest. Then, the rice company extends its land just after forester companies clear the forest for wood purposes and for exportation to Europe (especially). It is just after the economic crisis in Cameroon around 1984 that this company closed down. Coupled with Franc cfa (Cameroonian monetary) devaluation, nothing was done anymore according to large farming and farmers' support. In Center forest region, and before 1984, few populations were living and especially feeding by harvesting natural fruits and hunting too. Now with the increase of the population in Cameroon (2.2 %), sustainable forest harvesting, population in Nkoteng can concentrate themselves in majority in formal rice plantation. We remember that, more than 95 % of the population in Nkoteng lives basically on agriculture, because it is a rural area. Since 1992, many NGOs have want to work with farmers' groups and they have formed a group of farmer associations to cultivate their lands, using rotational cropping methods which take enough land but avoid the use of chemical fertilizers. In this region, people cultivate perennial crop too to avoid shortages during dry season. This means that taking their land without compensation is a problem and if yes, brings food in that forest region for them. Another important issue is the time to take for clearing forest for another farm land, planting and harvesting: this needs more food for them within that period. Things are very different in tropical grass land of Cameroon as follows; here farmers work in group and have to evaluate their production to make a good sharing plan of product from post harvest period. In this region maize is an important ingredient for food preparation and does not take enough time to mature in the farm. It is also an important ingredient for farmers rearing animals such as fowl and others. That is why maize is cultivated by any farmer because it is very important at any time. That is why in Africa, the food aid is usually based on rice or maize. The second plant that is cultivated in this region by many farmers is cassava, but this takes around one to two years to mature. In 2008, farmers were organized in a group practicing the traditional large scale cultivation (more than 10 hectares) and any farmer has also a private small scale farm (less than half hectare). But the community farm is a priority for farmers because of group obligations.

2-5-2 Land use history in tropical grass land of Cameroon

This region has accidental relief and obliges inhabitants to occupy a favorable area and raises animal on mountains or rest of non occupied area. This factor classifies the region as one of the highest quantity of inhabitants per kilometer square. The agriculture on mountain did not keep sustainable of soil fertility because of erosion. All these factors coupled with boom of population increase within these four years imposed a real problem of lack of land in grass land region. Kumbo region, our sample is one of the important regions as an example. Here the percentage of educated people is high and

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very open to new ideas; that is why they can practise agro-forestry and multiple cropping to sustain their agriculture and solve grapping land problems. The education brought them into books and borrowed some sustainable agricultural technologies from their neighbours (Nigeria). The small scale (around half hectare) agriculture is an obligation in those conditions.

In conclusion, the problem of land for agriculture taken suddenly without any parallel compensation is an important issue in tropical rain forest. This problem is also coupled with inadequate land for household in grass land region. This can be explained by the high cost of land in this region.

Cereals are very important in those two regions especially their important place in traditional balance diet in the two regions and their important place in domestic animal balance diet. By the way, only maize, beans and groundnuts as cereals is usually cultivated in these regions of study.

2-6 Production cost for biofuel

Large scale biofuel's production will probably tend to increase the prices of agricultural commodities. This may benefit some farmers but may hurt these food buyers as they will be unable to afford food. For sure, the poorest people will benefit if they get involved in the ''added-value'' of biofuel processing or production. The evaluation of biodiesel's price will depend on feedstocks from which the oil or liquid is extracted. Feedstocks comprises 50 to 70 % of the production cost for ethanol whereas biodiesel feedstock comprises 70 to 80 % of production cost (Worldwatch Institut 2006). The following Table

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shows the price differences between the two types of biofuels (alcohol and biodiesel) compared to gasoline or standard diesel.

Table 2.3: Ethanol and biodiesel production cost compared to fossil fuel in some countries (OECD 2006)

	Ethanol	*Gasoline*	*Biodiesel*	*Diesel*
		(Euros per energy-equivalent litre[a])		
US	€0.36 (corn)	€0.45 (with tax) €0.32 (without tax)	€0.50 (soy)	€0.47 (with tax) €0.31 (without tax)
European Union	€0.70 (wheat)	€1.09 (with tax) €0.34 (without tax	€0.56 (rapeseed)	€1.06 (with tax) €0.33 (without tax)
Brazil	€0.27 (sugar cane)	€0.69 (with tax) €0.33 (without tax)	€0.52 (soy)	€0.40 (with tax) €0.32 (without tax)

Table 2.3 above shows that considering the same feedstock (example soy), the price of final product (biodiesel) can be different. This depends on regional system as for example, the difference between temperate and tropical regions. World watch Institute (2006) pointed out that, policy makers have worked hard especially in Brasil to foster domestic ethanol and determine by force the ethanol prices and trade barriers, to be very sure that benefits remain only within their borders. This justifies the fact that only 10 per cent of ethanol is traded in the world (World Watch Institute 2006).

Another factor to control the biofuel prices is Glycerine which has helped to reduce the final biodiesel production from €0.04 to €0.08.

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Feedstock choice can significantly influence the final price of liquid biofuel. Table 2.4 shows that the production of feedstock can be evaluated by their yield or productivity per hectares. This means the number of liquid biofuel (in liter) per hectare.

Table 2.4: Biofuel production per hectare by chosen feedstocks and within some important regions (World Watch Institute 2006, Kaltner *et al.* 2005)

Crop	*Typical yield (litres per hectare of cropland)*				
	US	*European Union*	*Brazil*	*India*	*Malaysia*
Ethanol source:					
Sugar cane			6500	5300	
Sugar beet		5500			
Corn	3100				
Wheat		2500			
Barley		1100			
Biodiesel source:					
Palm oil			5000		6000
Rapeseed		1200			
Sunflower seed		1000			
Soybean	500	700	400		
Jatropha				700	

This table 2.4 shows that only *Jatropha curcas* as a second generation feedstock and can be produced in tropical areas. Brazil and Malaysia are the major producers and the success there is also based on decentralization system (Worldwatch Institut 2007); that should be why United Nations (2007) claim for a sustainable system where farmers can share in the whole system. Small scale producers have negligible percentage of whole production (Kaltner *et al.* 2005**,** Fulton *et al.* 2004). The system of profit share is prioritized.

On the contrary, Pimentel *and* Pimentel (2008) studied the production price of some biofuels through many developed countries. They found out that the cost per kg of biodiesel from sunflower is around Euro 2.1 These figures were obtained by calculation of all input and output for production.

2-7 Energetic aspects of biofuel production

There are many types or forms of feedstocks used for biofuel production. Municipal solid wastes and animal manures are usually used to generate or produce methane for the use as energy in some municipalities and on-farm too. Ethanol as fuel has been generated in a commercial way by using starch for biofuel factory and feedstocks from sugar. But in Cameroon, there is no appropriate collection and use of municipal solid wastes. By the way, the co-generation energy production from incineration or landfill process is not both applicable and introduced in Cameroonian energy policy; but the new technologies of feedstock production are still new coming and financed by western countries (private sector).

Nowadays, looking for good feedstock is important and to avoid driven cost of food. It is true those green energies and their related technologies are also needed to ensure entire global stability by reducing significantly the harmful effects of fossil-fuel based energy consumption. In this way, the evaluation of green energy in reducing chapter of the world difficulties and problems and established one sustainable energy system is very important target taking into account a transition to green energy economy (Barley 2007). This author highlighted the importance of finance input for the green-energy that is based on sustainable development. Everybody knows that huge investment requires a proof return to ensure the sustainable investment; this is why the calculation of Energy

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Returned on Energy Invested (EROEI) is very important. This term exists in ecological, physic and energy economics (ViKipedia 2009_b). The formula is given in (1).

$$EROEI = \frac{\text{Usable Acquired Energy}}{\text{Energy Expended}} \quad (1)$$

If I consider the net energy (gain), I realize that it measures as EROEI, the quality of the same energy source. The amount of energy is measured by net energy while EROEI measures or describes the efficiency of the production energy process. The relationship between the net energy and EROEI is shown by formula (2).

$$(\text{NetEnergy} \div \text{EnergyExpended}) + 1 = EROEI \quad (2)$$

In fact, it can also be defined as Energy return on investment for an activity/usually considered energy invested from society.

This formula shows that the break-even point occurs when net energy is 0 implies that EROEI equal to 1.

It is then interesting to consider the economic impact of EROEI variation. For instance when EROEI is high per capita in terms of energy use, it is desirable because of its link with high standard of living which is low in Africa and Cameroon too. According to (Wilkipedia 2009_b) the EROEI of wind power in Europe and North America is 20:1. The one for biofuel should be higher than this because of some cost such as transport cost. This means they use 20 parts of fossil or other sources of energy to produce one part of energy; the ratio will decrease with time till reverse. But many authors do not believe the measurement of EROEI which is based on simple physical process. In the same way,

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the fossil fuel to invest in biofuel production in time is not available in quantity; this can be proved by the variable cost of petrol every year and which causes many taxi men to strike in Cameroon periodically. The externalization of biofuel producing cost is another issue that is not well considered. The assessment and choice of biofuel feedstocks is an important issue to consider before cultivation and transformation (World Watch Institute 2006).

If considered to divide biofuel feedstocks in two nowadays interesting categories, biodiesel and ethanol feedstock it is possible to discuss the possibility of a good application in Cameroon. The assessment can be based on feedstocks types and coupled with production process.

-Types of Biofuel

The Figure 2.2 shows the comparison of some feedstock production per hectares.

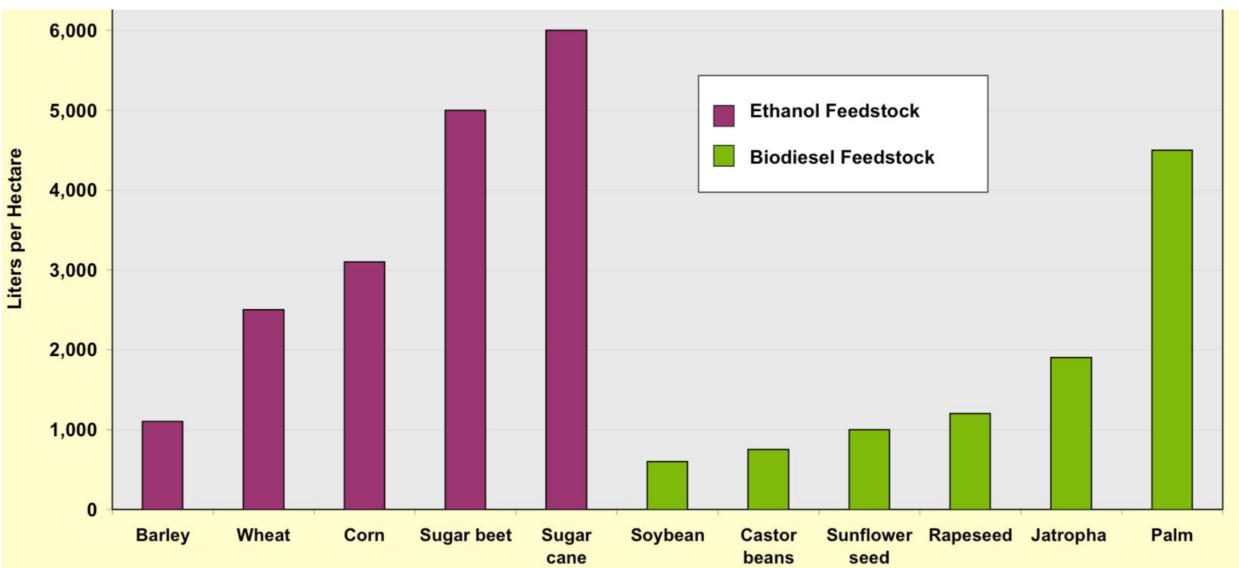

Figure: 2.2 selected ethanol and biodiesel feedstock yield (World Watch Institute 2006 and reported by Barney 2007).

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In this figure above, I can obtain that the production of ethanol is usually higher than production of biodiesel feedstocks. In fact, for ethanol production the feedstocks to consider in case of Cameroon are maize and sugar cane (*Saccharum spp*); the biofuel feedstocks to be considered are *Jatropha curcas* and palm oil (*Elaeis guineensis*). The consideration of these plants for Cameroon is based on their possibilities to grow in tropical areas like Cameroon. Other plants such as barley, wheat, sugar beets are not usually cultivated in tropical areas. Castor oil, rapeseeds and sun flowers are also not recognized or not yet well experimented in Cameroon and many Sub-Saharan Africa countries. Considering that the production of maize is insufficient to feed people in Cameroon (MINADER 2008), it is logical to exclude maize as good feedstock for ethanol in Cameroon. It was reported that SOSUCAM, NOSUCA and SUMOCAM three sugar companies in Cameroon produce only 146 000 tones/year and they also estimate the deficit of sugar in Cameroon. The deficit is between 30 000 to 50 000 tons per year (MINADER 2008). This means that sugar cane is also excluded as a sustainable feedstock ethanol production in Cameroon. At the same time some countries in Sub-Saharan Africa faced with the growing price of sugar immediately when started production of ethanol or alcohol with sugar. It is not advisable in case of Cameroon with this huge gap of sugar production for human food. In conclusion, the production of ethanol in Cameroon has not yet started because of collapse of sugar supply for food.

If production of ethanol based sugar, the supply of sugar for food should be dramatic.

It is still the field of biodiesel to evaluate which can be based on soya bean, Jatropha and palm oil. Worldwatch Institut (2007) has precised that, looking for second generation biofuel feedstock is better than fuelling cars or engines with food. This can be demonstrated by the driven cost of palm oil in Cameroon in 2008. In fact SOCAPALM, an oil company in Cameroon is just using a small quantity for fuelling engines. The next phase to increase the quantity of palm oil as engine's fuel should multiply the actual palm oil price at least 3 time. In fact, the price in Douala town (one of the largest population town in Cameroon) usually doubles when the scarcity occurs and automatically increases in dry season because of lack of water (reduction of palm oil tree productivity). The activation of palm oil for biodiesel can become a tragedy for Cameroonians. Many authors such as Worldwatch Institut (2007) and Drapcho *et* al. (2008) highlighted the benefits of second generation feedstock biofuel which do not have direct impacts on food prices or production. *Jatropha curcas* can also grow in marginal land to valorise them and are perennial crops to protect the soil against erosion for good land conservation.

The entire North of Cameroon is faced by desertification due to Sahara desert and climate change and the deforestation is a major problem in that area. In the same region, many NGOs such as WWF in Chad, Cameroon, Central Africa Republic and Nigeria highlighted the reduction of Lake Chad surface from 26 000 Km to 1500 Km from past 50 years: this was the largest lake in the world. They also highlighted in the speech of President of Cameroon (Paul Biya) during the sixty-fourth conference of United Nations in September 2009. The degradation of land in that region is significant and Jatropha can grow in marginal lands (FACT FOUNDATION 2006). Per hectares, the production of Jatropha per hectare is relatively acceptable around 2 000 Litres/year (Figure 2.2 below) compared to other biodiesel feedstock if disqualify Palm oil, sugar cane and maize. The why and the how this *J. curcas* can grap farmers' land is the remaining question here.

-Conversion of biofuel feedstocks

The relative energy of each feedstock is very important for a good choice of producing feedstock. It is also good to know that energy conversion processes in large number takes place in nature, such as solar radiation factor, photosynthesis, latitude and altitude, temperature that determines the growth rate of plants (Sorensen 2004 and Drapcho *et al*. 2008). Based on two different conversions of feedstock to ethanol of biodiesel, I can discuss whether or not it is advisable to Cameroon socio-economic conditions.

Concerning the ethanol production process, the equation below describes the process:

$$C_6H_{12}O_6 + 2Pi + 2ADP \rightarrow 2C_2H_5OH + 2CO_2 + 2ATP + 2\,H_2O$$

Glucose → 2ethanol + 2carbon dioxide + energy

Glucose is a sugar extracted from some feedstocks such as maize and sugar cane. With glucose it is possible to produce alcohol (ethanol). In contrary for these above mentioned equations, for production of ethanol the biodiesel production has a simple path or process as found in figure 2.3 below.

-Biochemical process for sugar/starch crop (Figure 2.3): To obtain sugar from crop (maize and sugar cane), the hydrolisis is used here before fermentation with microorganism; the hydrolysis is to add enzymes or acids to glucose as demonstrated on the equation above. The hydrolisis is also the fact that cellulose is composed of a long chain of sugar molecules (glucose) and should be broken down with *Saccharomyces cerevisiae / Zymomonas mobilis* in fermentation as found in Figure 2.3 below.

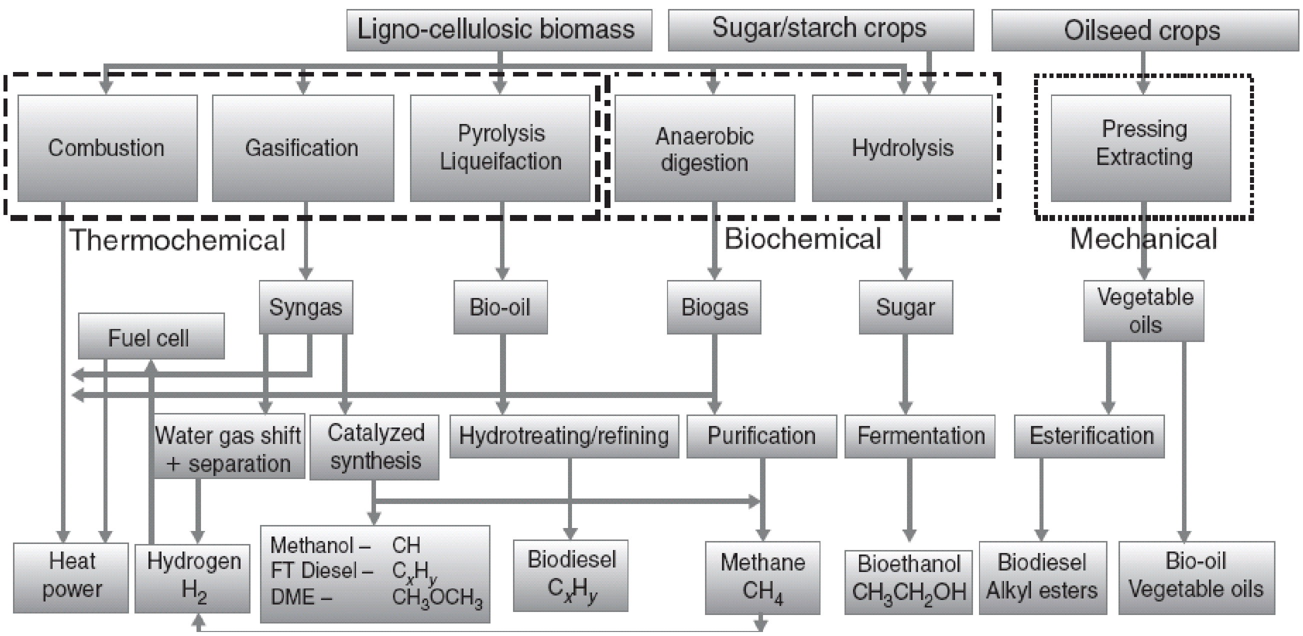
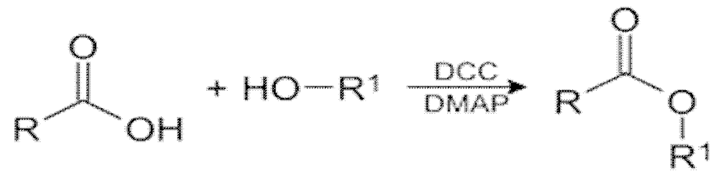


Figure 2.3: Main conversion of biomass proposed by Letcher (2008).

The biodiesel processing is based on mechanical extraction that Cameroonian farmer knows from palm nut experience. The oil extracted from *J. curcas* can be used directly in converted biodiesel engines or pass through the process of esterification to be used in conventional engines. The following equation below (3) expresses the esterification process to have final biodiesel if washed with clean water.

 **(3)**

These above equations especially for ethanol production are not 100 % efficient. Drapcho *et al.* (2008) has shown that hydrolysis equation yield theoretically around 70% before fermentation which is not too far efficient. The efficiency decreases because of formation of other types of alcohol different to ethanol (xylose, glucose, arabinose, arabinose, mannose, galactose, glucose, xylose). The biodiesel still becomes efficient because of its extraction manually by lay farmers and can be used directly in engines. Looking forward for production of better feedstock for Cameroon case per hectare, it is possible to calculate and found out that *J. curcas* yields at 1890 l/ha (Drapcho *et al.* 2008).

2-8 Next generation feedstocks in the years beyond

According to Worldwatch Institute (2007), bioenergy is very useful not only as a source of liquid fuel (bioethanol or biodiesel). It is still possible to also include production of heat, power, clothes, plastic and production of bio-based products. In this case of biomass abundance, co-harvesting and biorefineries can significantly lower the cost of final biofuel litre. United Nations (2006) noticed here the larger array of these feedstocks. After first and second generation biofuel feedstocks, it is noticed that waste sources of cellulosic biomass will be the provider of first influx of ''next generation'' feedstocks. The reasons to consider cellulosic biomass attractive is to use waste biomass that created an added value in the society, displacing fossil fuel by a product that will decompose, occupying no additional land either marginal or agricultural land

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(Worldwatch Institute 2007). Fast growing energy perennial crops on slopped land (where erosion let impossible to grow food) with short rotational woody crop and grasses will help increase carbon in that soil. These wastes biomass also include municipal waste that will reduce or eliminate the landfill cost of waste. It is also attractive in terms of easier way to store cellulosic biomass compared to sugar-based feedstock. Many authors have shown that *J. curcas* can be grown by intercropping with seasonal crops. In addition, the difficulty is to break down some cellulosic biomass and convert to liquid.

Drapcho *et al*. (2008) have shown that cellulosic biomass is composed of three components which are cellulose (~50 %), hemicelluloses (~30%) and lignine (~20%). From the Figure 2.3 above, through biochemical process, cellulose and hemicelluloses can be transformed to bioethanol and lignine to chemical or other product. It is also possible to transform all the three components to a ‘’syngas’’ which can be transformed through thermochemical process to synthetic biodiesel. Wood or trees with high lignin can be transformed to a diesel fuel by gasification or thermochemical process (Figure 2.3). The alternative of using agricultural biomass is possible in regions where biomass is high enough because a remaining biomass will serve as land cover or carbon returns to productive soil.

As a concern, *J. curcas* is growing in agricultural lands or waste lands. The growth is rapid depending on the local temperature. If the temperature is higher, the first harvest is 6 months and for around 50 years. The technology of breaking down the cellulosic biomass at first stage is not yet well developed (Worldwatch Institute 2007); but *J. curcas* can be used to produce biodiesel from oil, valorize waste land, protect sloped

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field, intercropped to reduce land grapping and the straw from grain can be used for biogas production and the tree for fuel wood (FACT FOUNDATION. 2006).

Calculation of energy need from biomass

The ''next generation'' feedstocks as defined above also includes agricultural residue and organic waste. Worldwatch Institute (2007) and Worldwatch Institute (2006) have estimated through a method of net energy output depending on region characteristics.

-The formula to calculate energy (Er) from the agricultural residue in a particular region is as follows:

Er = Regional production of food X Co-production of residue X amount of residue that can be sustainably harvested.

This does not take into account other alternative use of agricultural residue such as animal food and rural decoration.

-The formula to calculate energy or ethanol (Ew) from the organic waste in a region is as follows:

Ew = The average person quantity of municipal waste generated per day X population number in that city X percentage of predominant cellulosic material X 330 l/tones of ethanol.

That is why Drapcho *et al*. (2008) estimated that harnessing biomass energy range widely and depend on population size, the yield of both energy crop and food, and per person demand of land and food. Biomass theoretical demand could be huge and rivaling oil supplies. Since the conversion technologies of the next-generation are still on the verge of viability, *J. curcas* have some potential to be used and valorized especially

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in Sub-saharan regions. This could explain why within only 5 years ago, many producers of *J. curcas* in western countries invested enough for it in Africa and Latin America.

Calculation of *J. curcas* potential that is needed in Cameroon.

The Table 2.4, it was found out that *J. curcas* can be a promise feedstock due to the comparison with other feedstock. From there, the yield per hectare is 700 litres /year in India (World Watch Institute 2006, Kaltner *et al.* 2005). Drapcho *et al*. (2008) came through this evaluation and found 1890 l/ha/year in USA. This depends on the cultivation technology (here is mono-cropping), soil nutrition and climatic conditions. By considering that production in Cameroon can reach at least 1290 l/ha/year as the mean of these both productions above, it is possible to determine the total hectares to reach the needs of the population.

In tropical grass land like Kumbo it is 235 000 inhabitants that are living (Kumbo Urban Council 2006). According to Drapcho *et al*. (2008) calculations, 1 litre of biodiesel from Jatropha can produce 9.25 Kwh. Making a calculation for Kumbo region in Cameroon, it is logical to find 11932.5 Kwh/hectare with mono-cropping and 5966.25 Kwh/ha with inter-cropping, considering half intercropped area. If I considered the 40 poor farmers cultivating Jatropha through Greenery Association facilities by intercropped them, it is possible to calculate the contribution of biodiesel in their lighting system which is 5 Kwh/person. In total it is 2400 kwh/year for all of them and then 2.5 hectares for the feedstock cultivation. This is possible in such region with intercropped to stress the food rising issue. In some localities in tropical rain forest in Cameroon such as some villages at Nkoteng, there is no electricity. This technology could be more interesting and attractive if managed very well the *Jatropha curcas'* feedstocks (Worldwatch Institute 2007).

CHAPTER III: MATERIALS AND METHODOLOGIES

3-1 Localization of the study

3-1-1 Spatial localization

Geographically, the study localities are in Cameroon. The mechanized or industrial are in the Centre region. The second region where small scale *Jatropha curcas* or bioenergy cultivation system is practised is the Northwest region. The industrial plantations stand from 4^{o}00 N to 5^{o}00 N and from 11^{o}05 E to 12^{o}05 E. The small scale farms (Northwest region) are located within precised geographical locations: from 10^{o}00 E to 10^{o}05 E and from 5^{o}09 N to 6^{o}04 N. The first region (towards Yaounde and its environs) included Mvila, Nkoteng, Mankim and Batchenga. The second region includes Bamenda and its neighborhoods. Figure 3.1 shows the locations of both regions.

3-1-2 Climate

The centre region is characterized by bimodal tropical rainfall forest with rainfall ranges from 1500 - 2000 mm / year and 2 distinct wet seasons (short and long). The Northwest region has a different climate with 1500 - 2000 mm / year and 180 days of rainfall.

3-1-3 Soils

The soil is very fertile and suitable for agricultural activities especially in tropical rain forest region: young soils (inceptisols) on steep slopes; highly leached soils (oxisols) in the old uplands; soil with B layer with alluviation in closed depressions. This upland is enriched with volcanic materials. In the centre region where Agroil and Venture Energy Ltd operate, the soils are mostly ferralitic, bleached, clay and red or yellow depending

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on the length of the wet season with a low retention capacity nutrient which depletes quickly.

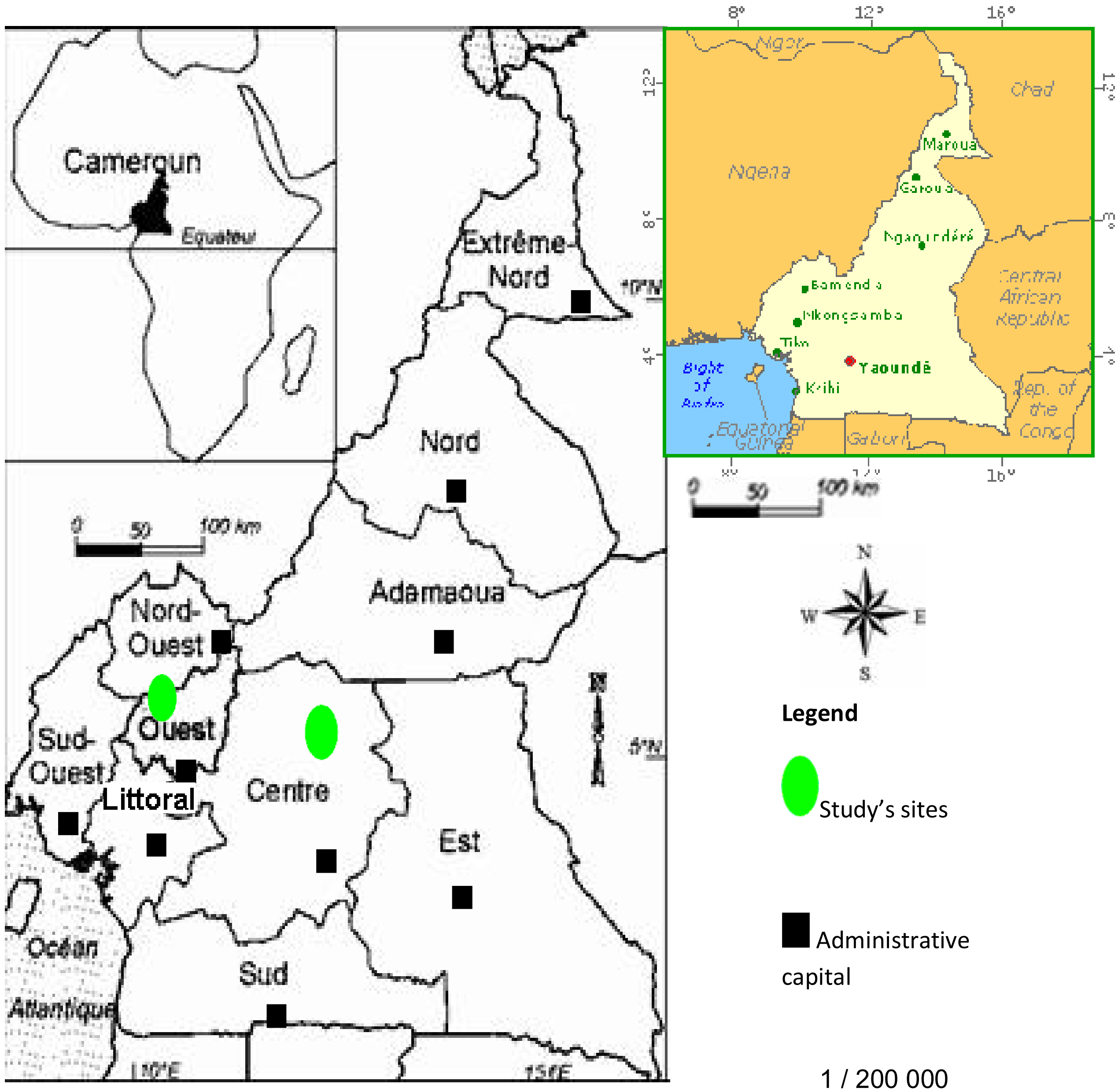

Figure 3.1: Map of Cameroon showing the locations of study's sites

3-1-4 Fauna and flora

In these two regions, it is possible to find *Jatropha curcus*, *Lophira alata, Coula edulis,* many cereals, various tubers and orchards. In the centre region, all types of tropical trees and tropical animals are present due to huge amount of neighbouring forests.

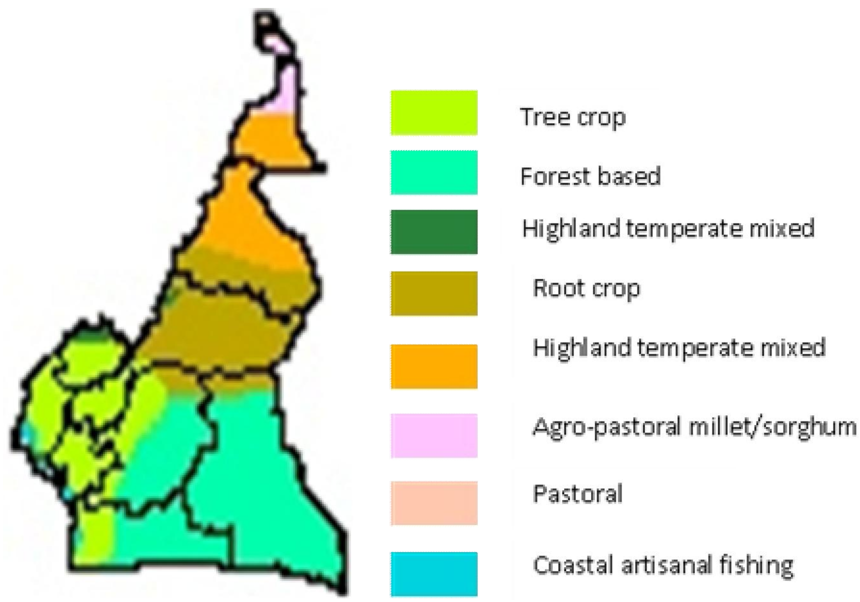

Figure 3.2: Farming system in Cameroon (Adapted from FAO 2009_a)

Figure 3.2 above shows us the difference between the two regions: Tree crop and forest based crops.

3-1-5 Socio-economic characterization

Agroil Company has implanted its plantations in high population density regions that is; Yaounde, Capital of Cameroon which is a city of 1.430.000 inhabitants (Wilkepedia 2009).

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Socio-economic characterization of tropical rain forest (Nkoteng)

In this region, the rural area is occupied mostly by poor farmers. Nkoteng is an administrative subdivision in Cameroon but more than 95 % of population relies on traditional agriculture. In fact, it is a forest region and most of the activities have relationship with wood exploitation by foreigners and sugar cane cultivation in the region and all in large scale. According to some farmers, this locality was created because of the need to park wood from forest and to assemble hand labour for sugar cane farms. After some years of the devaluation of Franc CFA in Cameroon in 1994, it led to the increase of cocoa trees destruction because of low selling cost. Farmers are still looking for new lands to replant cocoa again because of high cost of cocoa per kg in the world markets. This area is not suitable for coffee cultivation. Before, farmers focus towards food crops cultivation. Some food crops in small scale are local banana and palm oil (that are not selected species and some time grow spontaneously in farms or bushes) to make their own oil palm if they cannot afford some time to buy a litre of refined oil. Groups of farmers also cultivate some seasonal crops such as cassava, yam and especially maize in small scale to sell in their traditional periodic markets. From there if possible, they can buy some low cost clothes and shoes. Maize is an important product because it is use in different types of foods and to get money by selling to others from town. In the past 90% of proteins was obtained from bush meats, but nowadays maize is an attractive product to raise some fowls (in traditional system). A large scale of rice cultivation was done in Nkoteng village, but when the rice Company left because of economic crisis just before 1994, farmers distributed amongst themselves the farmlands

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to cultivate their food crops (in small scales). In the contrary, tropical grass lands in Cameroon have some particularities.

Socio-economic characterization of tropical grass land (Kumbo region)

This area is located to the North Western region of Cameroon. One of the major particularities here is the high level of education as compared to the previous area above. In the same comparison, majority of the people in the area speak English language and are more open to science and rural development.

After the devaluation of Franc CFA, farmers could not afford to sell their coffee products and destroy their coffee plantation to plant what they could consume directly. It has been noticed that coffee (Arabica and Robusta) is not consume in Cameroon as compared to western countries. Farmers have learnt quickly to plant palm oil for household processing and use when they cannot afford to get a litre of refined oil in the market. There is no large scale food agriculture here; just a new large scale of *J. curcas* farm belongs to an NGO's Himalayan Institute.

The overall of the agricultural system is based on small scale cultivation; many farmers have pieces of land below 1 hectare to feed their family per year. They can cultivate maize (*Zea mays*) which is very important, beans (*Phaseolus vulgaris*), soya beans (*Glycine max*), potatoes (irish and sweet), yams (white and yellow), tomatoes and bananas. All are farmed in traditional way or improved agriculture in small scale. The first problem here is land; this is usually justified with the number of land problems jugde in Bamenda (the largest city in the area with competence to arbitrate disputes between the inhabitants). This region is well known as one of the most populated areas in the North western region of Cameroon. There are small markets which help farmers to sell their products to buyers from Douala town far away (about 500 km to the region). To reach kumbo village, from the nearest two (Bamenda) which is just around 100 km, villagers need one or two whole days on the road and by car if there is no rain, because of hilly nature of the region and no tarred roads.

3-2 Methodology

3-2-1 To define the amount of vegetable oil, grain exported specially for biofuel and the cereals imported.

This assessment has an objective to explore the relationship between the global food crisis in Cameroon and the rise in biofuel feedstocks production/exportation. As highlighted before in literature review and supported by FAO (2008), cereals is the most consumed product in the weekly diet of the inhabitants and it also constitutes more than 60 % of animals diet that will produce protein for human beings. That is why food aid in Africa is usually maize from USA or rice from China, which is easier to cook with less energy or to make different meals too.

To achieve this, I was able to get some data from the data office of Douala Port Authority concerning the importation and exportation of agricultural products and their destination or purposes. I focused on first and second generation biofuel feedstocks and cereals as soon as possible. The data analysis before 2008 (January 2008, food protest period) was used to stress this point. These assessments showed the quantity of oil for biofuel exported before the food crisis demonstrated by poor and hungry people. After analysing these data, it is possible to look for the difference between the amount of food (especially cereals) that was exported for fuel and their corresponding gap in biofuel feedstock cultivation region in Cameroon; the rise of food price over time should be used as an indicator.

3-2-2 Define the spatial distribution of biodiesel feedstock and their interaction **with fertile lands.**

To achieve this step, I was able to design or find maps of the two regions of study where *J. curcas* is cultivated, showing the distribution of biodiesel feedstocks found in the field. The overlapping or distance between the biofuel farm cultivation and favorable food farm land were highlighted. The type of feedstock cultivation or farming was also highlighted with interaction of population concentration and for the specific towns where people protest against food crisis in 2008. Priority was given to *J. curcas L* (Figure 3.3). This clearly showed us the impact of biodiesel production on favourable farm lands. It also showed the differences between cities where protests took place and the cities where no protest occurred and also found the biofuel production direct impacts on farmer activities around these protest areas rather than in the whole country. That is why the population percentages or number was highlighted. The type of farming demonstrated the future impact on the environment according to their geography; that of course had more impacts on food production. This was stressed with a method described in section 3.2.6.

Figure 3.3: One of *J. curcas* seedlings site in AGROIL's plantation (Nkoteng)

Basic maps were obtained from the Yaounde Urban council and from Agroil offices in Yaounde, and also from Kumbo council too. The field trip was conducted in more regions (agricultural offices and rural area) such as Northwest region and Centre region of Cameroon in order to have information on local percentages of land use for biofuel feedstock. I visited some regions such as Kumbo in Northwest region (council, Himalayan Institute, initiative group of farmers), Nkoteng and Nanga Eboko in Center region, so as to have to get the cultivation biofuel problems and system of the whole regions.

The software Mapinfo was used to build some maps or make some modifications. One GPS was used to record the spatial coordinates in each locality in the region.

3-2-3 Define the impacts of second generation biofuel feedstocks on soils quality/quantity in Cameroon.

One of the lands used for second generation feedstock factor was evaluated using data from each region. The soil analysis was assessed from literature that was in the critical zone around Agroil farm in the Centre region. I took some (5) soil samples in one chosen ½ hectare of *J. curcas* plantation; the physical description of lands was done about the adaptation capacity for cereals or for pasture according to the zic-zac method

(Baize and Jabiol 1995); this means I do not follow the same line on the field to take samples. This technique reduces many errors. The analysis of phosphorous, total nitrogen, cation exchange capacity, pH, organic material, exchange bases, all physical characteristics of soil profile and potassium was assessed. The comparison of lands used for second generation biofuel feedstock and land appropriate from minimum needs to grow cereals was done. The map above was commented again. With data recorded in different agricultural localities in Nkoteng, I was able to design an evolution curve for the trend in future years. Then, I used STELLA software to predict a potential scenario within some years in case of no new policy incentive. Another option is to know the cases that change can occur positively. I also used questionnaires (coupled with interviews), used Akoun *and* Ansart (1999) method to stress this point (see section 3.2.6).

Evaluate the production price of 1 ton of feedstock, its environmental impacts and propose potential mitigation measures for land use.

The administration of questionnaires was done to differentiate what happened in the field and the stakeholders target objectives. The association of Cameroonian consumers (''Association Camerounaise pour la Defense des Interests Collectifs'') provided me the data for the whole gap variation prices of cereal as food. The rest of the data was obtained from the Cameroonian Ministry of Agriculture and Rural Development. Farmers and some potential NGOs told us their own prices before I assessed it in the field through a method (in section 3.2.6 below). I took Agroil's farm as large scale feedstock second generation biofuel. Agroil will be taken as large scale producer for second generation feedstock; the chosen company was based on the one

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that cultivates *J. curcas*. Kumbo locality was taken as zone of small scale production system by farmers. Each system was assessed and each farming cost was evaluated according to their particularities. I proposed the biofuel on food crisis impacts mitigation according to the type of farming, impact to the soil fertilisation and intercropping advantages for food and environment.

Assess the impact of actual policy and propose an integrated reasonable policy solution in Cameroon.

The actual policy of Cameroon agriculture was assessed in terms of land distribution for biofuel feedstock to large scale usage of first or second generation. This was done by questionnaires (coupled with interviews) and using Akoun *and* Ansart (1999) method in section 3.2.6 below. NGOs, WTO (World Trade Organisation), UN (United Nations), FAO, AU (African Union), CEMAC (Central African Economic and Monetary Community), Governments, EU (European Union), Farmers which took important place in the actual policy was assessed. Their role was discussed. I set out the convenient policy.

3-2-6 Observations techniques and questionnaire methods

1- Physical observations

During the first visit of field recognization, I had to identify specific farms of presence of *J. curcas* in order to characterize their impacts on soil quality and quantity. In practised, the field trip was done and accompanied by the first test questionnaires (5 in Kumbo region and 5 in Nkoteng region) called "exploratory" (Akoun and Ansart, 1999). Then, during the final interview-questionnaire, some modification was done to approach the

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reality in the field.

2- Questionnaires

To get an idea of reliable sources of *J. curcas* in each region, a questionnaire (Annex I) was designed and administered exclusively to target bio-energy and agricultural stakeholders in the field. One way to have all data beyond the physical observations was the use of questionnaires (Abu, 1983), aimed at target groups or stakeholders of bio-energy feedstocks cultivation. The questionnaire was designed in a very concise and simple ways, and was accompanied by an interview so that no information escaped. I was the one who filled questionnaires during the interview and not the interviewee. The main characteristics of these questionnaires are:

-Open questions and closed questions

In the absence of any prior or existing model of questionnaires in this case study, I had tried with some open questions. The advantage was that during an exploratory phase, I allowed a stakeholder to express himself in wide spectrum of information or domain. This type of questioning helped me to mark the future scope of the questionnaire at first field visit (Akoun *and* Ansart, 1999) and the major drawback is to provide improvement, especially when the interpretation was difficult. The use of semi-open questions significantly reduced the margin of freedom to the interviewee, forced to choose answers from a non-exhaustive list of items proposed in the questionnaire or during questioning. In practice it was based on three main criteria of selection to avoid problems of sampling and comparison: the scope and analysis of non-responses, analysis of responses "majority" and the social profile of respondents. For semi-open questions, it goes without saying that the increase of possible items accentuated the accuracy of responses (Akoun and Ansart, 1999).

-Questions of fact and opinion questions

Akoun *and* Ansart (1999) recognized the dichotomy in the making fact of the questionnaire between questions of " fact " and issues of "opinion". For instance the question of ‘’fact”: (eg " Biofuel companies are occupying your land by force? ") Implies a response whose edges are very defined and unambiguous. The question of "opinion" (eg " You used fertilizer for farming?") (Appendix I) implies a much more equivocal. This type of questioning by the ambivalence and subjective responses that it is induced, it is prescribed by many sociologists (Akoun *and* Ansart, 1999) as having the first purpose of objectification of social phenomena.

However, it is noticed that, despite the inherent subjectivity of opinion questions, they cannot learn from an objective characteristic practice of social agents (on *J. curcas*), but on the plain meaning they attribute or perceive their interactions biofuel and especially *J. curcas*. It had previously identified the players involved who were directly interacting with the habitat of the *J. curcas*: biofuel cultivators, farmers, MINADER and others stakeholders from government. Some authors believe that the sample should be a scale model of the population, and therefore the distribution of variables must be the same in population and in the sample. This vision creates the "method of quotas". But it was used in this study the most recent and most difficult to use, rejecting "reduce model" and build a model of the distorted population, overrepresented in some categories in interaction with biofuel feedstocks and not for others. This approach to operate is known as the "survey of Neyman" (Akoun and Ansart, 1999). This makes sense from the moment we knew in advance that the parameter in relationship to the biofuel feedstock (*J. curcas*) that we studied showed a greater variability within a certain category of actors that we had chosen than others. This method improved the precision of estimates.

Each group randomly received questionnaires in their areas, interviews with at least 45% of actors, sometimes exceeding 80% of actors. Their home in which they were resting far from their farms was avoided as possible. In total, 32 questionnaires were administered in Nkoteng and 130 questionaires in Kumbo and 8 in Yaounde ministries.

-Techniques of interview-questionnaires

In the questionnaires sample (Annex I), there was a system of monitoring the veracity of the information received, sometimes had to repeat indirectly a further question that was asking in advance and to compare the two answers to conclude if the speaker was logical in his speech.

Further interviews were taking place very early in the morning for those who worked too late at night and very late in the evening and for those who worked during the day. The interview was held in the priority of farmers and decision makers who have a direct or an indirect interaction with biofuel feedstocks such as *J. curcas*, taking advantage sometime from the presence of *J. curcas* in their biological environments. I had to find some respondents (actors) at home or in their farms. I did not take appointments except in the case of highly organized decision makers. I have also visited some sites several times to meet the sufficient number of stakeholders that interact with biofuel feedstoks. I used an approach called disciplinary planning and thoughtful questions with specific words. Finally, a Professional Conduction was adopted for the other person considers the importance of the study and especially the interview. After the greeting, I introduced myself and summarized the significance of the study (Abu, 1986) with the interview and suddenly the interview began. The level of education of every actor gave a particular style of framing, language level and issues following each type of questions. To some who were hostile or conditional by asking for a paid before discussion more, I took advantage of the beginning oral communication situations and drove it between actor and researcher pursuing an objective for a finding. Instead of this direct influence, it sometimes provided me comfort and pleasure in a climate of trust and friendship. But this technique took a long time in the field and patience for me.

-Processing of questionnaires

After the coding or design of a model before a sample questionnaire, the SPSS version 12.0 for Windows has facilitated the counting. This software facilitated the understanding of the driving force of biofuel on employment, land and others parameters.

CHAPTER IV: RESULTS AND DISCUSSIONS

4-1 To define the amount of vegetable oil exported specially for biofuel and the cereals imported.

This assessment was to explore the relationship between the global food crisis in Cameroon and the rise in biofuel production or vegetable oil demand. As I previously defined the focus of this assessment based only on first generation feedstocks, the DPA (Douala Port Authority) statistical office was visited for the issue.

Firstly, no data was available on second generation feedstock such as *Jatropha curcas*, castor oil or seeds and *Pongamia pinnata*. These feedstocks were introduced into Cameroonian's agricultural system 3 years ago and the production has not yet begun to be exported. At the same time, no processing plant for second generation biofuel was yet constructed in Cameroon. More than 5 plants are in project for construction, especially in Northwest (small scale production of biofuel feedstock) and Centre region (large scale production of biofuel feedstock) of Cameroon. This means that no importation of raw material from other countries for transformation can occur; that is why I could not find any data on import or export of those specific biofuel second generation feedstocks.

Secondly, I found in those statistic data obtained from PAD that before April, 2008 (month and year of food shortage demonstration), the global importation of cereal (especially rice and maize) was more than 4,200,000 tones. These curves (Figure 4.1 and Figure 4.2) show the trend of agricultural strategic product in terms of importation or exportation.

Highlighted in advance by FAO (2008), cereal is the most important food for human being in terms of their nutrients content, availability everywhere in the world possibility to make many meals and also important input percentage in animal food.

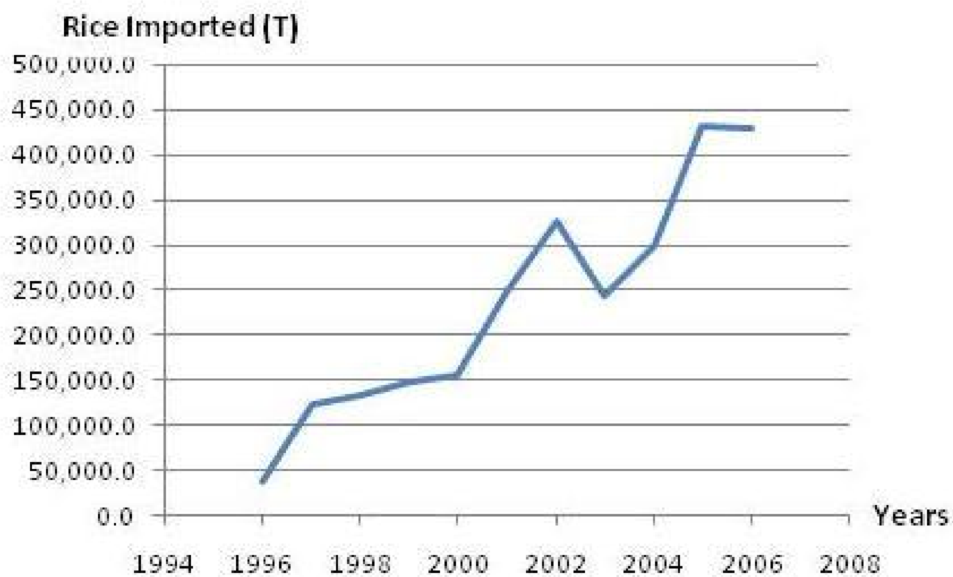

Figure 4.1: Rice imported in Cameroon in the past 11 years.

It is understandable from this curve that the importation of rice increases each year. The demand of rice is high because of increase in population and change in daily meal. Poor people prefer to eat what is easy to cook like rice in order to benefit from cooking energy resources. Rich people prefer to cook rice in another way where the use of rice is in high quantity and quality. The importation of rice increases more or less exponentially as shown on Figure 4.1. This happened from year 2000 to 2002, because of the legislative election in Cameroon in 2002 which obliged some politician to import rice to distribute for buying votes of poor. After 2002 (after election), it is then normal that the curve decreases drastically because of the post election which does not need to buy votes. From 2003 to 2004, the amount of rice imported increased quickly due to land grapping for rice cultivation. In fact, the cultivation of *J. curcas* started in 2006, and before that the land for maize cultivation was collected for this biofuel feedstock cultivation. The importation quantity was supposed to increase to reduce the cost per kg of rice. According to Goufo (2008), it was found out that 87% of the demand for rice is imported to Cameroon in 2008. It was found out from questionnaires and interviews that there is no policy to manage biofuel cultivation. On 2006, the quantity of rice imported stabilized and started decreasing slowly (Figure 4.1), but the demand of rice increased exponentially due also to civil war in Chad that started in 2005 where they need rice from Cameroon (from Douala Port Authority). These factors caused the price of rice kg and the poor protested against this on 2008, because they did not have more alternatives: At Nkoteng where people did not have another alternative to cultivate land (because use for biofuel: *J. curcas* and *Saccharun spp*) for alternative food protest too. The analysis of maize importation was also possible below (Figure 4.2).

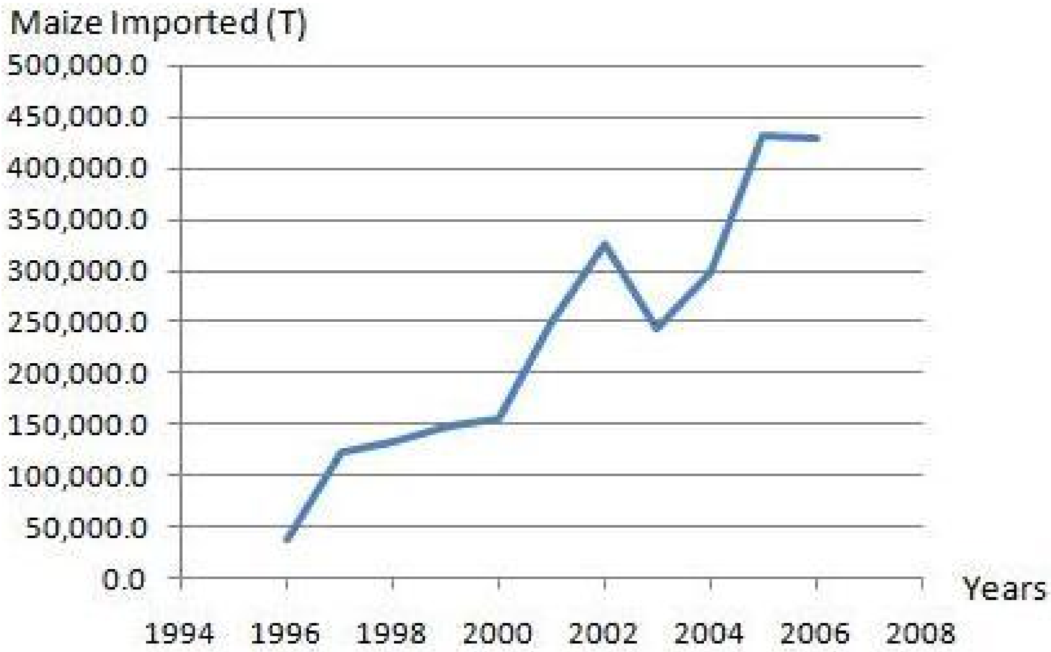

Figure 4.2: Maize imported in Cameroon in the past 11 years

This figure 4.2 above shows more or less the same trend like the figure 4.1 for rice import. The correlations between these two curves demonstrate the same role of cereals in African nutrition or the first place of cereals in human nutrition (FAO 2008). The difference between rice and maize is that, maize is easier to cultivate by farmers than rice but both can be used for the same purposes. I realized also that the introduction of biodiesel feedstock in agricultural sector has started in the same region where food protest occurred since around 2006. In fact before the planting of feedstock, the land grapping effect started before to ensure the coming period of cultivation.

It is difficult to justify or understand the exportation of food for fuelling cars from Cameroon where the increase in population number passed from 12 million inhabitants in 1995 to 18.4 million in 2009 (IFAD 2009). Considering the following curve (Figure 4.3), I understand the gap of an important food preferring to fuel car instead of feeding humans.

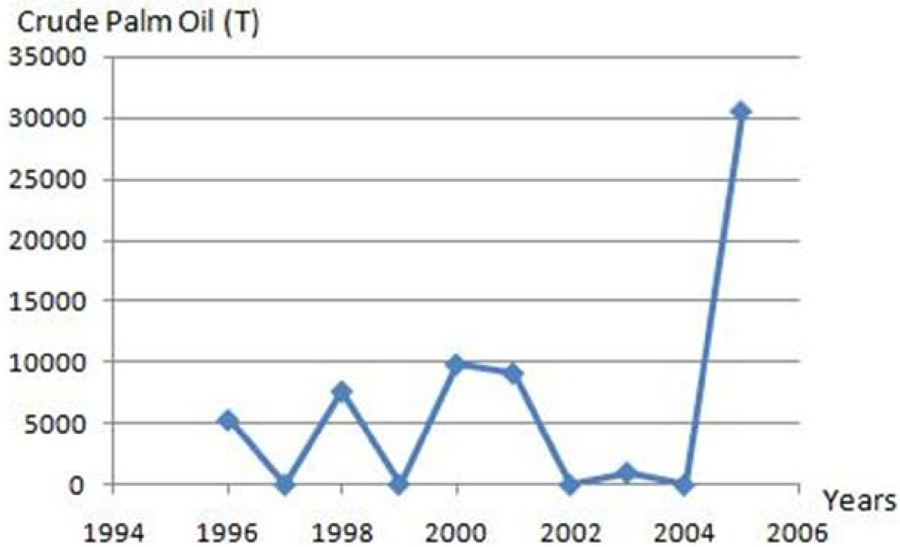

Figure 4.3: Crude palm oil exported from Cameroon

I found out that exportation of palm oil from Cameroon is mainly to Europe where the attraction for biodiesel is a priority. On the figure 3.6, the importations have never been 0 tone / year. In 1997 and 2004, the exportation is in reality, less than 50 tones / year due to both presidential elections in Cameroon as I explained above for the rice case. Because soap is also distributing enough before elections to buy votes from poor and soap is made essentially with palm oil. In 1999 and 2002, it is still less than 50 tones / year exportation of palm oil. This is due to oil palm trees (*Elaeis guineensis*) productivity and for election preparation especially in 2002. The problem of food crisis occurred when from 2004, the exportation of crude palm oil increased exponentially from 5.6 tones / year to more than 30,000 tones / year in 2005 (figure 4.3). I remember that the cost of a litre of crude palm oil in local market was too high in 2007 and some rich people could not have the possibility to buy more because of no availability of this oil. More than 90 % of this palm oil exportation is for Europe, especially for biodiesel production and use in Europe. But, this oil is an important ingredient in many traditional foods in Cameroon; for instance in western region and Kumbo region of Cameroon where I investigated (with high population density), this oil is use at least 5 days a week for daily meals. This demand from Europe has driven the grapping land of farmers in Littoral region for palm oil production and using of palm oil at SOACAPALM (largest Palm oil producer enterprise in Cameroon) to dry crude rubber (*Hevea brasiliensis*) and to run electric generator engine (Libert 2007).

All these above showed the relationship between using food for biofuel and food crisis by exporting food for fuel or by occupying food's land for cultivating "car's food" (see the next below in section 4.3 and section 4.2).

4-2 Define the spatial distribution of biodiesel feedstock and their interaction with fertile lands.

From the field research, using different efforts to have the exact distribution of population per small localities, it was not possible to have these data. In fact, it was not possible to have access to those data in National statistic centre of Cameroon. But in some localities such as Bankeng village, it was possible to have the number of inhabitants through the village chief or district head. The Figure 3.1 has shown at the beginning of the methodology the two different regions to work. Here I have to assess and highlight the distribution differences between the two system of *Jatropha curcas* cultivation and two regions. Only two regions were chosen in the field because of limited financial resources and also for their differences to show or find the objective. The case of small scale *Jatropha curcas* cultivation is very interesting in the Northwest region.

4-2-1 Small Scale Cultivation of Jatropha curcas in Cameroon (Northwest region or tropical grass land: Kumbo)

According to FAO (2009_a), Northwest, West, Far North and Centre regions of Cameroon have population density between 501 to 1000 inhabitants per square kilometer. These regions have highest population numbers and the increase rate of the population is 2.1 % and that of the rural population is 44.5% (FAO $2009_{a,}$ INS 2002). Small scale *Jatropha curcas* cultivation is found in rural area of Northwest of Cameroon. The following map (figure 4.4) shows the distribution of all the localities constituting the *J. curcas* network in Kumbo region (Northwest Cameroon). At the same time, these regions have some localities with more than 1000 inhabitants per square kilometer (region inside the circle; figure 4.4).

The Greenery Association and Himalaian Institute are two NGOs acting in Kumbo region and are based there. They act as seedlings producers since 2 years ago and will stand for feedstocks buyers after harvesting, will process them and resell to villagers. Greenery Association works directly with farmers' groups in those villages on the Figure 4.4; starting from the inner circle on the map to external localities. But, Himalaian Instutute works with agricultural technicians in Kumbo. These technicians are supervisors of agricultural technology transfer from Ministry of Agriculture and Rural Development to farmers: this makes this network more organised. Himalaian institute also have for itself 27 hectares of *J. curcas*, some plots of lands for castor (*Ricinus communis*) and *Pongamia pinnata.*

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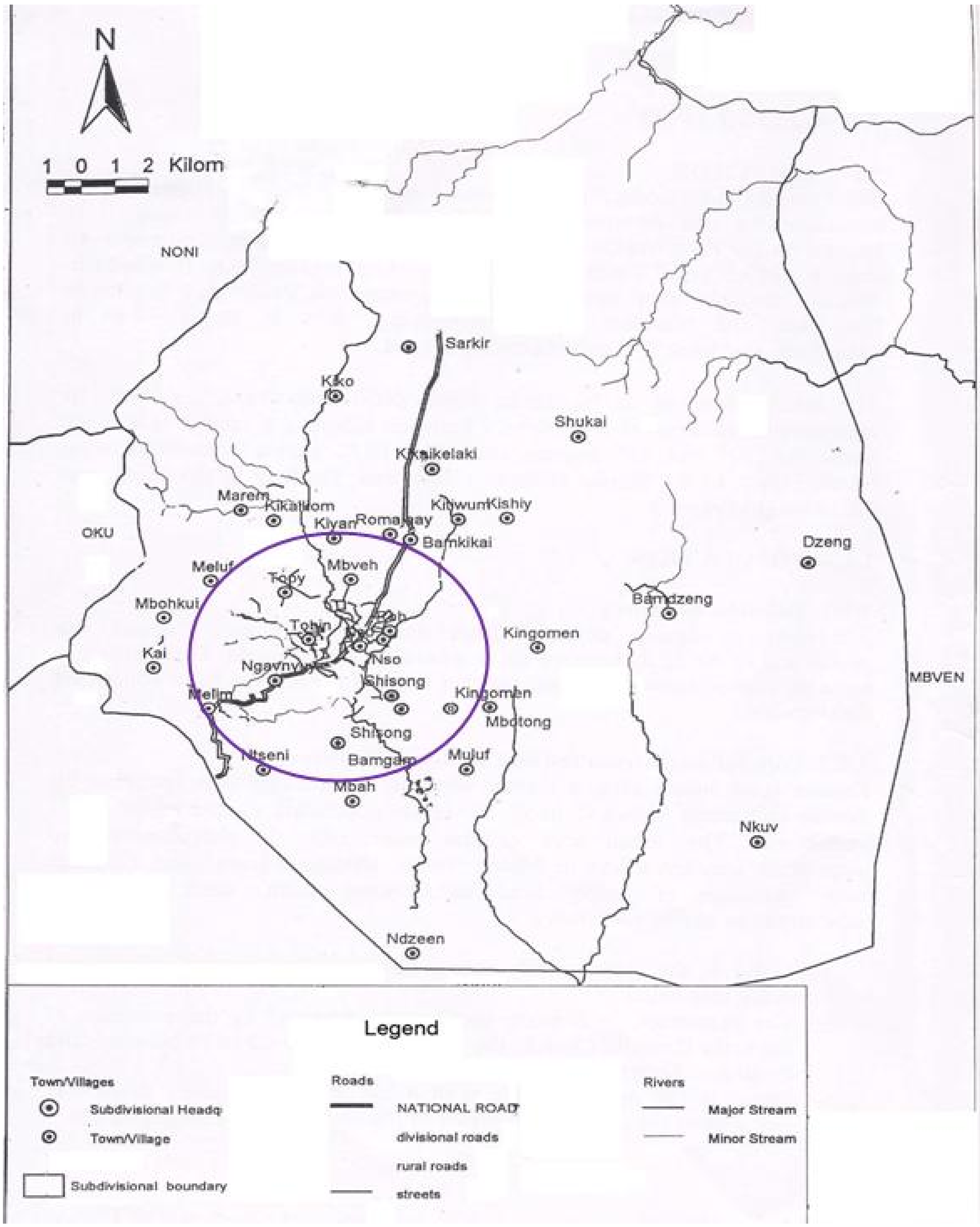

Figure 4.4: Map of Kumbo showing difference localities for decentralized *Jatropha curcas*'s cultivation (basic map from Kumbo Council Mayor: Njong Donatus and (KUC 2006))

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In Himalaian Institute, Sunflower is still for experimentation around their office as shown on Figure 4.5.

Figure 4.5: Sunflower in experimental plot around the Himalaian Institute

The interesting observation that can be made from Figure 4.4 is that people develop the farms around the national road, reducing the time and energy for transportation. This facilitated the transport of product after harvesting, along the national road where people live, where the lands are very expensive and rare. From the populated places (such as Nso in the circle: figure 4.4) to the borders of Kumbo subdivision (south, East and North; outside of the circle) there is less population concentration; because of marginal lands (such as too much mountains and infertility of some soil) or reserves for pasture. But, Himalaian institute has developed for itself 27 hectares of *J. curcas* in pasture lands which reduce considerably the surface pasture or food for animals. I highlighted this issue because this institute does not practise the intercropping very well in pasture land to make sure that lands should be always good for food or pasture production that will finally feed human beings. But in farms, either controlled by both NGOs, the intercropping system is an obligation. This is very interesting. In general,

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98 % of farmers in the system use intercropping system to plant *J. curcas*. They intercropped *J. curcas* with more than 3 different seasonal crops in their individual plots as illustrated in Figure 4.6 below (*Jatropha curcas*) plant intercropping with maize (*Zea mays*) and also beans (*Phaseolus vulgaris*).

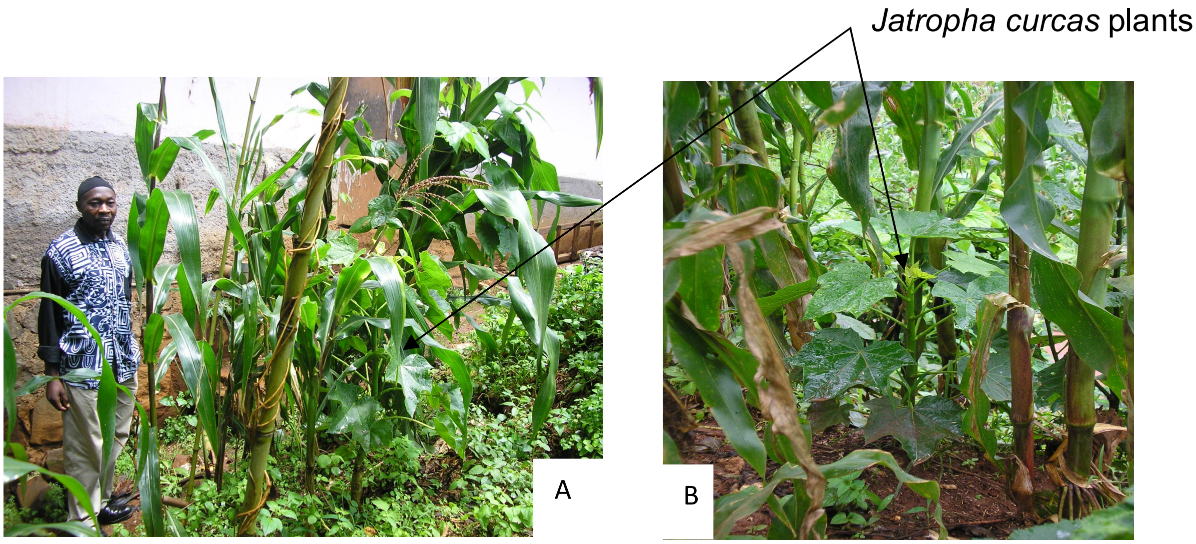

Figure 4.6: Farmer inspecting his plot of *J. curcas* intercropping with maize (A) in Nso village. In (B), is the plot for another farmer in Jakiri (south external border of Kumbo[3])

In Himalaian Institute network, I found the total of 15 hectares of intercropping *J. curcas* that have been planted in all farmers' farms. The population of Kumbo is around 235 000 inhabitants (Kumbo Urban Council 2006), and at this moment, no perturbation or problems in agricultural production system has been made in farmers' farms due to biofuel feedstocks. In fact, 85 % of these categories of farmers declared that "we have discovered the added value (or surplus) on our agricultural output". More than 85% of farmers did not have change in their products compared to the amount of land that they have cultivated. At the same time the food protest activists did not act enough in that

[3] Outside of the circle on the figure 4.4 (map)

region; they just suffer the increase in the prices of all goods that they cannot cultivate in their region. But after 15 years, the plants (Jatropha) can have up to 7 meter canopy as found in Ndop[4] bushes; this means that, the reduction trend of farmer's lands will be up to 50% if the interspaces of *J. curcas* are very small (or remaining less than 8 m such as I found in some place). This is based on those local seeds that farmers use at the moment. The figure 4.7 demonstrates how some farmers added some value to their agricultural output system by harvesting local seeds (none selected species) from bushes, animal fences or traditional fences to sell to Himalaian Institute or Greenery Association (NGOs), beginning of the *Jatropha curcas* production system in Kumbo region.

Figure 4.7: One farmers in Nso (Kumbo village) region, presenting some traditional seeds; ready to use with his children or to sell

Compared to 27 hectares cultivated by Himalaian Institute, 20 groups of farmers are still cultivating in Himalaian Institute Jatropha system. These farmers have found very helpful when they plant the *J. curcas* in marginal lands; because this reduced

[4] Region far away from Kumbo; 40 % of the seed of *J. curcas* cultivated in Kumbo comes from Ndop.

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considerably the erosion and competition with agricultural land which could occur before 15 years (such as highlighted below). The confirmation is given by the figure 4.8 below. In fact picture B below shows how the maize has yellow colour instead of green; thus the production of maize from these marginal soils will be very low. That land is poor because of erosion, it is on virgin hill and the red colour demonstrates the absence of arable soil useful for plants nutrition.

The picture A just makes a closer view of picture B (Figure 4.8).

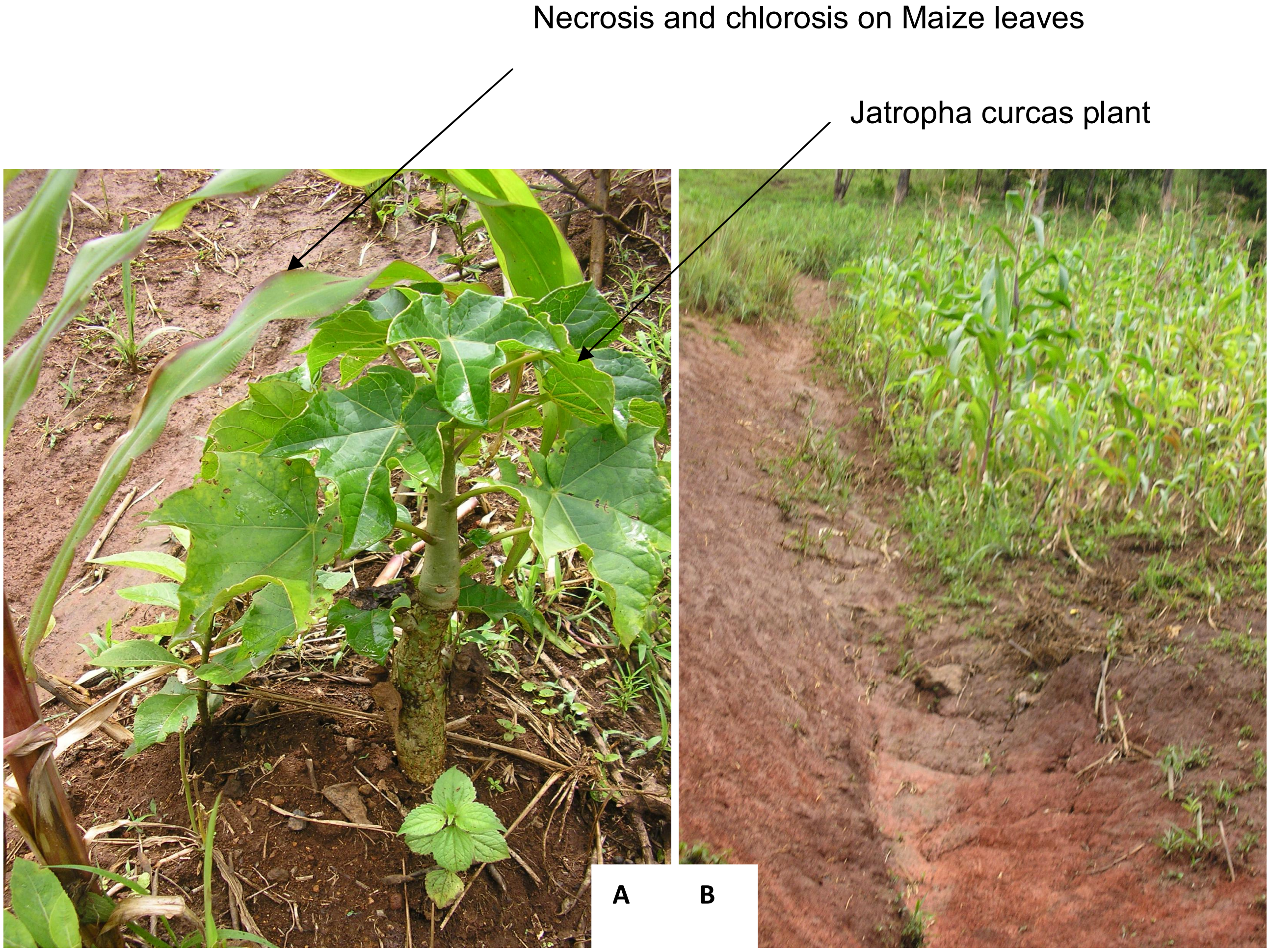

Figure 4.8: Pictures A and B show the resistance of *Jatropha curcas* on marginal lands which is not suitable for maize.

This picture demonstrates again the reason why some farmers plant them there to have a surplus in the future and reduce also the erosion by this method as land conservation method (Kuypers *et al.* 2005). Here *J. curcas'* plants are healthy. Meanwhile, I observed the maize plants with chlorosis and necrosis on their leaves[5], showing the limited nitrogen in that soil. The hill is another obstacle to apply fertilizer which is expensive to farmers, because of erosion which erodes the fertilizer; and this marginal land is also valuable by using *Jatropha curcas*.

In addition, *J. curcas* seeds from Ghana, Togo and India do not succeed very well in Kumbo region. Beside of the area (27 hectares) with mono-cropping of *J. curcas* by Himalaian Institute, more than 20 groups of farmers are using their pieces of lands for *J. curcas* cultivation (more than 15 hectares in total) in which they have intercropped with maize (*Zea mays L*), beans (*Phaseolus vulgaris*), groundnuts (*Arachis hypogaea*) and others seasonal (with around 4.5 months cropping cycle) crops. This none intercropping of 27 hectares reduce transhumance zone for cattle (NWDA *and* MIDENO 2006). More than 13 groups of farmers working with Greenery Association also intercropped *J. curcas.* Another factor is the use of marginal land as observed in Figure 4.6. The intercropping also plays an important role in land conservation, the land ‘’ that we are borrowing today from our future generation for sustainable agriculture’’: highlighted by one Greenery Association member. This technique used to control erosion with *J. curcas* is multiple cropping method (FACT FOUNDATION 2006; Kuypers *et al*. 2005).

[5] Red color on maize leaves' borders; it is possible to see yellow color too on maize leaves (see figure 4.8).

Good intercropping also helps in some farms to control the spread of diseases by increasing plant distance of the same family (Van Heurn and Van der post 2004).

4-2-2 Large scale Cultivation of J. curcas in Cameroon (Centre region: Nkoteng)

The industrial cultivation or large scale farming of *J. curcas,* has another effect on land availability for agricultural system and of course the effects on driving food crisis. The explanation of the following map (Figure 4.9) will help to understand how this works.

When we take a look at the map, it is possible to confirm that we are in an industrial system where small scale agriculture does not have its place. In the contrary, the majority of population relied on small scale agriculture in Cameroon which is justified by 48 % of poor farmers living in rural area (FAO 2009_a). The proof of this is that the plantations (Mankim, Ngila, Nkoteng and Batchenga). Large scale enterprises are situated along the single railroad line (orange color line on the figure 4.9) that links North and sea port through Center region of Cameroon. This means that the production is not for local use or even national consumption. The production is only for exportation, because of the construction of oil storage facilities (such as oil tank) in Douala sea port. This storage construction is designed to store the entire liquid biodiesel such as highlighted previously. But, the director of Venture Energy Ltd (S/C Mr Issa) in Cameroon has insisted that their production will be focused on rural utilization by farmers to reduce their energy demand. After I questioned and interviewed all stakeholders, I found out that this entire oil quantity will be exported to Italy in Europe for end use distributors. Let us now discuss about the field trip output in Nkoteng village to appreciate the results: Firstly, I chosed that principal village compared to Mankim, Ngila and Batchenga, because of many reasons:

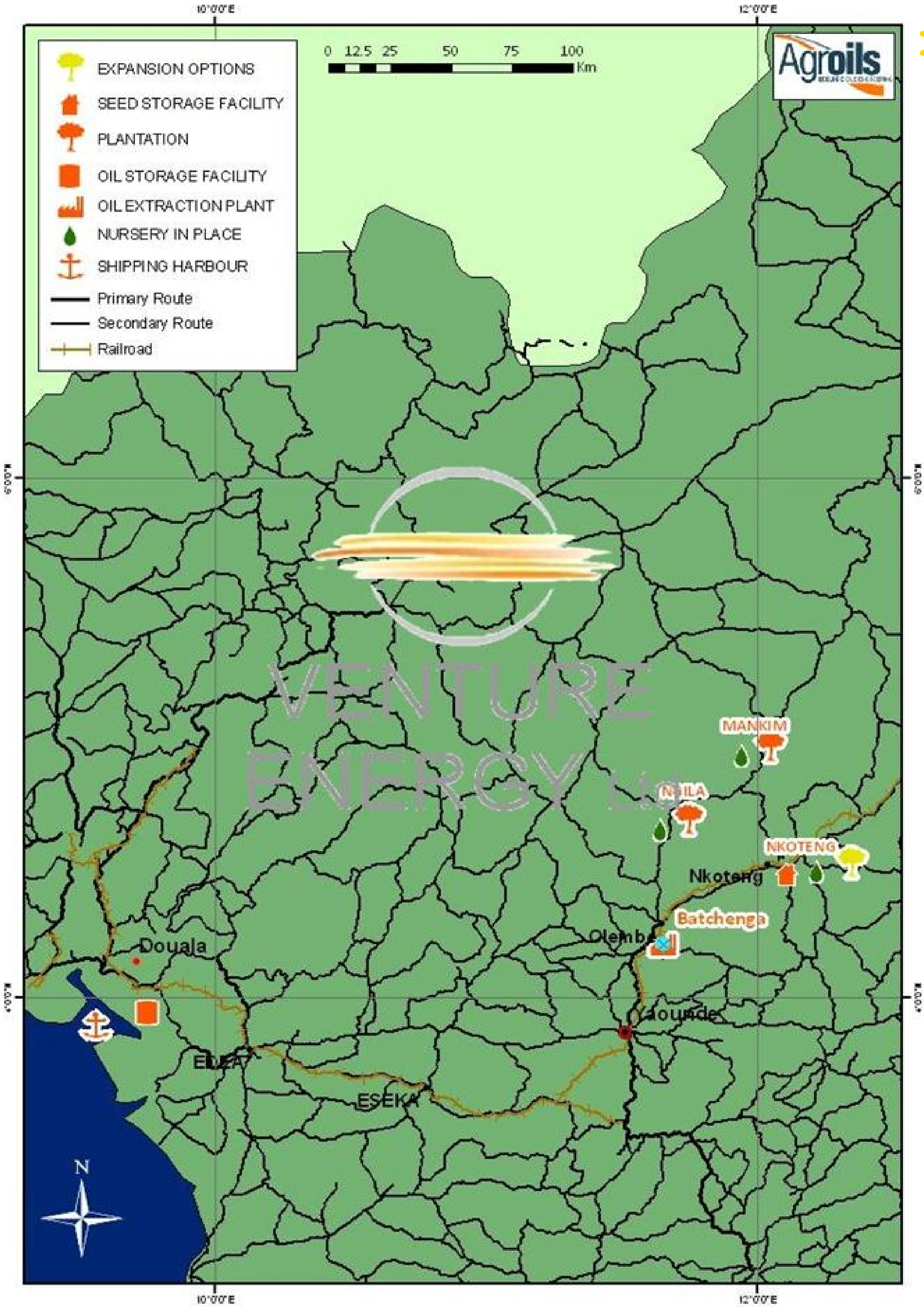

Figure 4.9: Distribution of Agroil plantations in Center region Cameroon (Adated from Agroil Office of Douala).

-Nkoteng is a region that has *J. curcas* nursery as seen on the map (Figure 4.9 and picture on figure 3.3 above) and has one present *J. curcas* plantation.

-The extension of *J. curcas* plantation on both sides of the river is highlighted in Nkoteng region as highlighted by his Highness the Fon of Bankeng Village in Nkoteng.

-In Nkoteng region, it is possible to find more fertile lands and different villages with lands that interact with *J. curcas* cultivation plantations.

-The last factor was the fact that I was kidnapped in Nkoteng (because of what a previous researcher did before me) when questioning some interesting sources to compare the version of Venture Energy director and relevant information in the field. Then I kept in mind that this is good location to find more information that stakeholders are hiding.

It was difficult to buy the basic map of Nkoteng region which was expensive. But also difficult to have access to data based on this target region where more environmentalists want to understand better on the land management with *J. curcas*: Bernard Njonga (President of ACDIC) is one of the activists against the use of agricultural lands for biofuel in Nkoteng.

One of the difficulties was the soil analysis that was projected in advance. This was not done at 100 % (10 samples). This happened because of complex negotiations for the issue with Venture Energy Ltd in Yaounde. Then only 5 samples were taken on a first cultivated land for biofuel, a land that belongs to farmers.

Impacts of industrial biofuels production on land reduction in Avangane village (Nkoteng locality)

The fertility of Nkoteng soil (see section 4.3 below) shows why many international agricultural companies prefer to invest in or near Nkoteng such as SOSUCAM (company for sugar cane) and also palm oil Companies. The food shortage protests in 2008 occured in Nkoteng. SOSUCAM Company also recognized the impacts of the protest on their activities at that period. After a survey in the two villages where Agroil and Venture Energy Ltd are cultivating *J. curcas*, the chiefs of Avangane and Bankeng villages revealed (Figure 4.8) many issues before the farm was assessed and at least 50% workers themselves even denied their work as employees for now. Akoum and Ansart (1999) method was very successful in the field as find author in action on those pictures (Figure 4.10).

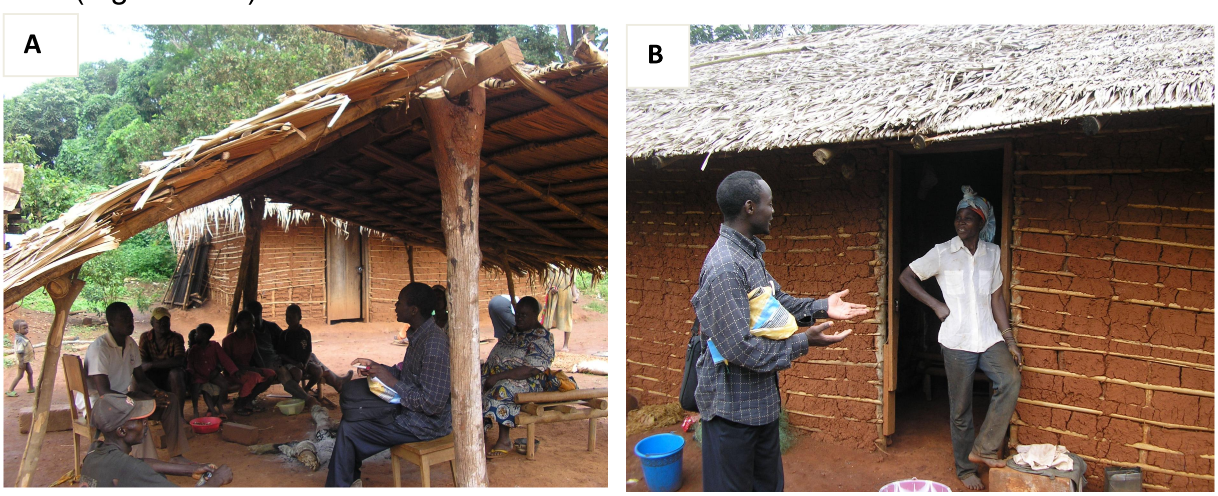

Figure 4.10: (A) Author's discussion with Avangane's Chief and others near the farm; (B) Interview coupled with questionnaire of one supervisor of Agroil plantation in Avangane near Agroil farm (Nkoteng).

After discussing strategically with all the stakeholders in the region, it is possible to say that about 10 hectares of present *J. curcas* plantation in Nkoteng is situated between

Avangane and Bankeng villages. Agroil and Venture Energy Ltd did not directly destroy the local forest which has impacts on climate and of course on crop productivity. Because of some environmental activists, Agroil and Venture Energy Ltd choose to use savanna in Nkoteng locality. This particular land was used by SENEMA (farm that was use before 1990) for rice and maize cultivation. According to the Fon of Avangane village, SENEMA reduces completely their activities from 1986 and left completely that savanna by 1990 because of financial crisis in Cameroon from 1987 and that conduct to FCFA devaluation in 1994. After departure of SENEMA around the Cameroon's social crisis period of 1990, villagers occupied this savanna land for agriculture (food production and for pasture). This occupation of farmers' lands for *J. curcas*, gave more reasons to farmers to clear the tropical rain forest for new lands. This forest is located in Congo basin forest, the second largest forest region in the world after Amazon forest.

Before understanding that Agroil and Venture Energy Ltd have in mind to extend their plantations which will destroy the forest automatically, let us discuss on present impacts. According to 100% of farmers, before taking 10 hectares for *J. curcas* seedlings, they were harvesting fruits and seasonal food (plants with up to month's life span) in at least 3 hectares and they cultivated 1 hectare before the Nkoteng mayor convinced them to leave the land to Agroil. According to Chief Bernard Beyega, no person has ever received any compensation from them for this lands; he asked me in the field confidentially that: ''what can we do in this situation to force them to compensate us?''. The savanna was also used to feed cows (especially in dry season) because *Brachiaria ruziziensis,* useful to feed cows was growing well there.

Another important factor is that Agroil and Venture Energy Ltd reduced significantly the man power in the village to work in *J. curcas* farms (in 2008, year of food protest) and never paid their salaries for at least 8 months ago. From the beginning of 2007, many farmers were working in the *J. curcas* plantation; after earning their salaries (less than 20 Euro/month) they did not find enough food on their local market because SOSUCAM drove the rest of farmers that were supposed to do farming. The price of food started going up and sometime unavailable in quantity. This caused a situation where all the workers refused to work anymore in Agroil farm after the food protest period. I assessed some data from Avangane's palace where farmers work in groups and need to quantify their production in order to facilitate the sharing of benefits at the end, and I confirmed the significant impact of industrial *J. curcas* cultivation on food crisis as seeing on Figure 4.11 below.

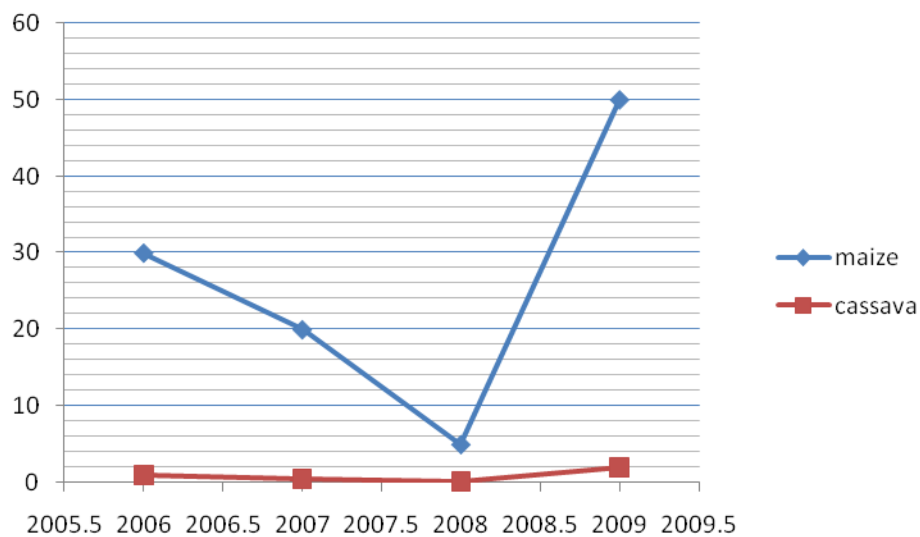

Figure 4.11: Variation of maize production in tons before and after February 2008 in Avangane village (Nkoteng).

Looking at this curve on Figure 4.11, the red color usually shows danger. In general, the production curve of maize decreased from 10 tons (2007) to 6 tons in 2008 (year of food

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public protest). Based on what villagers are harvesting this year 2009, the production will reach 50 tons for maize and 2 tons for cassava. The first interesting part of this curve is why the curve of production decreases in 2008 in the village! Agroil and Venture Energy Ltd started to use farmer's lands in 2006 and using man power from the same village in the same year. This factor caused the production of maize (principal food in that region) to drop drastically. By grapping farmer's lands and driving employment for biofuel production, the production of cassava also drop from 1 ton in 2006 to 0.1 ton in 2008 through 0.5 ton in 2007. The production of cassava low compared to maize because it is perennial.

After Agroil and Venture Energy Ltd occupied the fertile fields, other farmers that had not being recruited decided to clear the tropical rain forest for a new farm; but making a new farm in the forest is very difficult for farmers in terms of farm size and type of first growing crop which is not usually recommended to plant maize. The *J. curcas* industrial farm reduced the man power in the village at the end of 2007 to the beginning 2008 and also reduced the available farm lands for farmers and all existing perennial crops for farmers was destroyed.

The second interesting part of the curve shows the significant increase of the production of maize for up to 50 tons in this year. This positive slope of the part of this curve can be justified very easily by the fact that new farms in the forest can now produce more maize than the previous year. Another factor is what we can see on Figure 4.12 below. On that Figure, *J. curcas* plants and undesired grasses have the same height in more than half of the plantation surface, just because more than 95% of the workers in the village protested against the lowest salaries (less than 20 Euro /month). Agroil and

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Venture Energy Ltd promised them for a salary of 20 Euro/month, less than what they have if putting all the effort in their individual farms. But, employees spend about 5 months without being paid by Agroil. This has caused the farmers to go back to their new farms and put in all their efforts, thereby destroying forest again to have 50 tons of maize this year in 2009.

Figure 4.12: Undesired grasses left in the farm because of resignation of local employees originated from the village.

4-3 Define the impacts of second generation biofuel feedstocks on soils.

I was kidnapped in this region because of confusion between environmental activist, politician and environmental researchers (which is me). I highlight the difficulty of having access with materials to their farms for soil samples; it takes at least up to 3 months if accepted, more than the time delimited for this research. But I have succeeded to sample 1/2 hectare of biofuel land. The table below gives the results of soil analysis around Nkoteng biofuel feedstocks plantation on 1 hectare.

Table 4.1: Results of the mean of 5 soil samples (analyzed in IRAD, Yaounde)

Means from 5 samples	**pH**	**Na ppm**	**K ppm**	**Ca ppm**	**Mg ppm**	**Total N ppm**	**P ppm**	**CEC pH7 meq/100g**
	6.5	3900	5200	4100	2800	17800	4.8	11.8

This result shows that the pH is in basicity range (0-7). The fact that it is not too far below 7 keeps the nutrients available to plants cultivated. If not these nutrients should be binded and not available to consumption by plants. This pH is then good for Nkoteng soil. The value of nitrogen (N), potassium (K), phosphorus (P) and calcium exchange capacity (CEC) are respectively high than the quantity found in Centre region by Onana Onana (2006). Onana Onana (2006) found out that its own quantity fertile element was sufficient for maize, gardening cultivation standard. This means that Nkoteng soils used for biofuel feedstock cultivation is largely fertile for cereal production. The proof is that, farmers were using maize and some perennial crops production. These values are also high compared to what Golabi *et al.* (2005) found out better for maize fertilization.

It is normal or logical because Nkoteng or all Agroil's farms are located in forest region. Found in the field, these soils are deeper and usually black with more than 4 cm of dead leaves (organic material), which gives to them the properties of fertility. The fertility is also confirmed by the good vertical drainage (infiltration) of the cultivated soil in these regions and flat topography of the soil. This flat fertility is a good factor for rice cultivation, and that is why rice was cultivated long time before.

The high level of dead material on the top black soil explained the high amount of carbon stored in the soil and with time. Organic material on the top soil shows the good quality of soil because of that decomposition will take time: protect the soil against erosion and bring nutrients into soil (Van Schöll *and* Nieuwenhuis 2004). The soil was also very fertile for rice and maize in the past when the population density was very low in the region. This soil also contains an interesting percentage of gray, important for water retention for acceptable period before completely dry up. The Chinese company that used those lands was SENEMA as mentioned above. After I visited Agroil and Venture Energy Ltd in Nkoteng for many days with a local guide, I realized many things. Two plants of *J. curcas* have 10 metres as inter-space, compared to around 3 metres for normal intensive or mono-cropping of *J. curcas* advice by FACT FOUNDATION (2006). As the Figure 4.13 can show, no intercropping model is used in these farms.

Figure 4.13: Inter-space between two lines of *J. curcas* in industrial Nkoteng's farms.

No intercropping means that land is significantly not well managed as soon as the *J. curcas* land is increased. The estimation shows on 1 hectare in the field that ½ hectare is used and ½ hectares (sum of all rows area) are unused. Comparing with small scale cultivation of *J. curcas* in Northwest of Cameroon (tropical grass land region) that I have discussed above, I can say that industrial cultivation by this way is quality (fertility) and quantity wasting of land. At the same time villagers are struggling to destroy forest for new lands which is not suitable for first and some time second year of production and consume more energy: that is why Avangane's Chief Bernard Beyega asked one question during our interview that :''Can we go back to clear the grasses found in the inter-space of *J. curcas* in Agroil farms and plant any other crop that we can benefit such as cassava, yam and maize, considering that they may not pay us this time around if they want to kick us again?''. These questions confirmed again how important farmers are seeing their previous valuable lands under used by Agroil and Venture energy Ltd (Italian company). This effect was also found in EU's subsidies, by transferring lands for agriculture to forest plantations (Worldwatch Institute 2006, Faaij *et al.* 2003).

Evaluation of future scenario.

The table 4.2 shows some data collected from Bankeng village palace (at Nkoteng) and field. These data show the evolution of overall land own by Agroil through the time (from 2005 to 2009). These land include the area that is use to have access in biofuel farm or for other farm activities and that was cultivated by villagers. The production of maze data was also collected for each year and the projected quantity that farmers expected to have this year.

Table 4.2: Evolution of land grapping and maize production in Bankeng village.

	2005	2006	2007	2008	2009
Lands (ha)	0	6	12	19	26
Maze production (t)	40	30	20	6	50

By using Stella software, I can estimate the future trend of land grapping in Bankeng village. It is true that, Agroil has an objective to cultivate *J. curcas* in Nkoteng for at least 1000 hectares within and outside of Nkoteng village and in a short period. Farmers were cultivating 10 hectares of land that have been transformed significant area to *J. curcas* land in Nkoteng. If we consider 100 hectares, a part of SENEMA land that is not accessible by farmers due to ownership but accessible by Agroil, I can make a prediction of farmers land grapping evolution in large scale production. The figure 4.14 below gives the result.

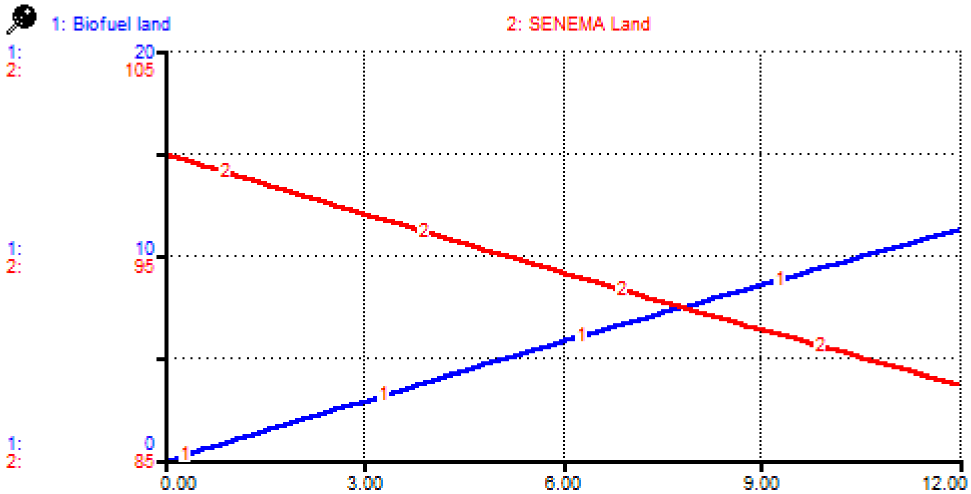

Figure 4.14: Evolution of land grapping by biofuel feedstocks cultivation in time.

I am observing on the curve that, the area of land grapping is higher than SENEMA land remaining area within 7.5 years from 2005 to 2012. But actually the land cultivated by farmers was only 10 hectares in that area, and was entirely grapping. Then if Agroil moves forward with his plan and at the same speed, 100 hectares of SENEMA land will become less than 20 hectares on 2016. But the plan of Agroil is not to move very gentle, it has a plan to import tractor this year to multiply the cultivated area times 1000. At that time 100 hectares can be cultivated within a month and not a year.

If there is any change such as good land management through intercropping we can have another different scenario in a figure below (figure 4.15).

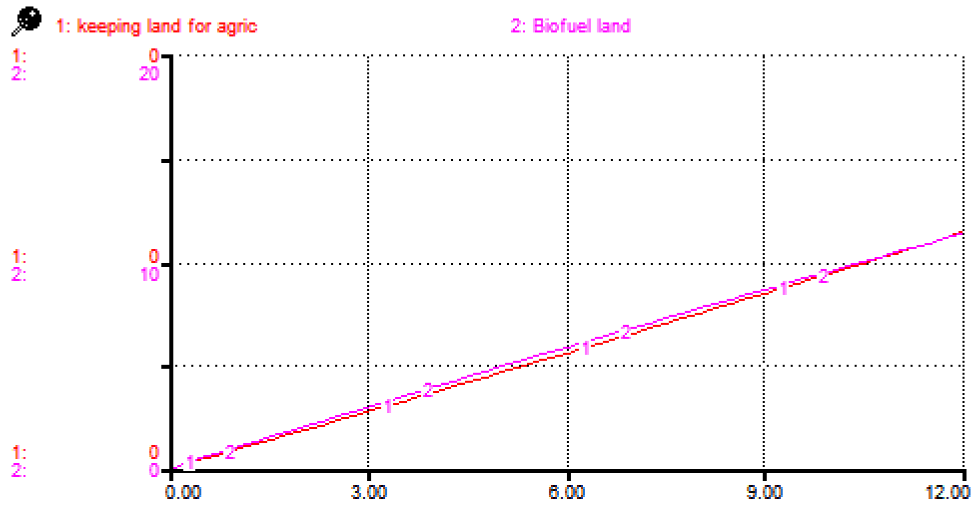

Figure 4.15: Evolution of land grapping intercropping system is introduced.

From what I saw in the field, in the area of 1 hectare of land without intercropping, at least ½ hectare was empty and covered by weeds. This area could be used to plant seasonal crops such as maize and yams. By keeping this trend, the curves above show that the area for agriculture will both increase through years. But biofuel area will not be far higher than agricultural land (‘’keeping agricultural land’’ on the figure 4.15). If Agroil started from 2005 with intercropping system, the area of biofuel will be equal to area for agriculture or food production. The curve of biofuel area is always higher than area for food production (Figure 4.15) because of the consideration that biofuel is planted before food crops. This demonstrates how the biofuel cultivation in tropical grass land (Kumbo) with intercropping did not have impacts on food security.

In summary, the soil used for biofuel production in large scale in Bankeng village (Nkoteng) is very fertile. That soil has all requirements to produce higher quality and quantity of cereals and other crops. Agroil plantation has impacts on food crisis by grapping land each year. If it follows this same trend, Agroil will grap 100 hectares by 2012. This can happen quickly with the mechanized programme of Agroil from 2010. If introduce intercropping techniques at the beginning, farmers will save half of the area (50 hectares).The actual biofuel programme is driving man power for rural food production without remuneration. At the end, the actual system of large scale is boosting the food crisis in Nkoteng (tropical rain forest) contrary to Kumbo (tropical grass land) where biofuel production (small scale) adds a surplus to farmers output.

4-4 Evaluate the production price of 1 tonne of feedstock, its environmental impacts and propose potential mitigation measures for land use.

In Cameroon, either in small scale or large scale production of biodiesel especially with liquid *J. curcas* as final product is not yet achieved. Any actor in the bioenergy sector struggles for the moment to handle the feedstock production. In small scale cultivation system in Cameroon, the majorities of plants have not yet yielded fruits for oil extraction. It is difficult to evaluate the cost of liquid biofuel or production cost of feedstock. In fact, farmers benefit from NGOs that buy the seeds of *J. curcas* from other villages (they harvest along cow fences or in bushes). At the same time the climate is not very suitable for rapid fruits yield, because of low temperature. Any plant usually yields quickly under a climate with high temperature. The evaluation of price should be very difficult in this region (small scale production).

In large scale production region, it is still possible to evaluate the cost of production for feedstock. As for Worldwatch Institute (2006) feedstock comprises about 70 t0 80 % of production cost of liquid biodiesel. Drapcho *et al.* (2008) highlighted that in the feedstock cost should be included. The fixed cost (loan, machinery for mechanization like ploughing and disking, fertilizing and other processes on the farm). The cost should also include operating cost such as insurance, salaries of workers, fuels for tractors and other costs.

In fact, to have an idea on feedstock production cost, I need to know the cost of machinery, seeds, fertilizers, pesticides, insurance, interest, labour, land costs. The employees use crude tools (no machine was used this year at Nkoteng, but will be used next year) and seeds are free of charge because only local seeds yield well in Nkoteng (Figure 4.7 and Figure 4.16). Fertilizers are not used for the moment and will be used next year. Herbicides have been used only one time and will be used more from next year. There is no insurance, no proof has been shown to demonstrate that the Agroil and Venture Energy Ltd bought the lands. The labour cost is variable (20 Euro to 25 Euro/month/worker) and there are some workers who have not yet received their salaries for the last 6 months; that is why other workers even come back to find a new farm by clearing down the forest. I can say that 6 months is usually more or less sufficient for *J. curcas* production cycle in this region.

Figure 4.16: Destroyed Jatropha's fence around SELE Bridge (near Nkoteng farm).

The following table 4.3 shows the different input parameter that was found in Agroil plantation case study. I collected some data from relevant sources and appreciated also in the field itself. This table below presents different costs from land preparation to harvesting cost of *J. curcas* seeds. The cost of offices, running office materials and managers' salaries was not included because of Agroil's privacy.

In Agroil, it was established that around 7 months, *J. curcas* can yield and the dry seeds can be harvested around 8-9th month. It is then established that the investment cost per hectare is 690 Euro/ha. Due to the quality seed (none selected) and the worst production of seedlings, the *J. curcas* seeds production is only 1.5 ton/ha (data found in farm) compared to up to 12 ton/hectare where there is higher precipitation (Openshaw 2000). But Agroil farm is located in rain forest region with higher precipitation. This productivity is due to bad management of the farm and no weeding at time such as observing on the figure 4.12 above. This is also due the use of none selected fertilizer at none appropriate stage of *J. curcas* growth.

Table 4.3: Table of estimates cost per hectare in large scale production in Agroil.

	Year 1			Year 1 (follow)	
Expenses(1 ha)	**Fixed**	**Variable**	**Expenses(follow)**	**Fixed**	**Variable**
Machinery	0		**Labour**	Materials(20)	480(8 months)
Seeds		Include in labor cost	**Land**	0	0
Fertilizer		90 Euro	**Tax**	0	
Pesticides		100	**Manufacturing cost**		
Insurance		0	**Environmental cost**	externalized	
Interest		0	**Buildings**		
Harvesting cost		Include in labor cost	**Transport cost**		
Total cost of feedstock production on field: 690 Euro/ha.					

The price of 1.5 t/ha of harvested products is 690 Euro. The price of 1 kg is 0.46 Euro. This cost is less than the cost of 1 kg of biofuel feedstock based sunflower which is 2.1 Euro found by Pimentel *and* Pimentel (2008) in Europe. This is why many funders for *J. curcas* in Africa come from western or European countries. Then the price of 1 kg of *J. curcas* feedstock is found for around 23% of 1 kg of sunflower price.

This means that the cost of one ton of fresh *J. curcas* is 460 Euro/ton. Considering that the cost of 1 litre of biodiesel from rapeseed in Europe is 0.56 Euro (OECD 2006) and knowing again that feedstock percentage cost on final cost is 70% (Worldwatch Institut 2006) and it is around 120 Euro at Agroil; I can say that the production feedstock cost in

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Cameroon is higher than in Europe. But, this cost did not even include mechanization cost that existed in Mankim as compared to the case of Nkoteng (where I evaluated the cost), insurance, and land costs that Agroil is not yet paying. This productivity 1.5 t/ha (data obtain on farm) in large scale cultivation is very low compared to 1909 L/hectare that Drapcho *et al.* (2008) found out in USA if we consider that 1kg of feedstocks is equals to 1 litre of oil (because oil content depends on soil quality, seeds quality, climate and extraction technology). If there was many fixed cost, the overall cost per kg will decrease throughout the year because fixed cost should be a discount from the first investment.

I highlighted above that small scale cultivation conserves the soil at present and helps future generations. The large scale system exposes the soil between each plant (10 m) to erosion. This system also reduces considerably the land for food, increases the climate change speed and bring the unpredictable food situation for future generation.

The cost in small scale cultivation at kumbo is very low in terms of the following factors: good inter-cropping system let avoid the use of pesticides, the shell from *J. curcas* grain after processing are use for organic manure, land preparation and weeding energies come from the same energy that are used for food crop in the same lands. Farmers can also benefit from wood harvested from *J. curcas* per year. Then it should be logical just to consider the cost of sowing, harvesting and some miscellaneous.

4-2-5 Assess the impact of actual policy and propose an integrated reasonable policy solution in Cameroon

Through the interview of the director of projects and programmes in central Ministry of Agriculture and Rural Development (MINADER), I noticed the responsibility of

MINADER about biofuels issues and policy in Cameroon. The results showed that MINADER is planning to accept the establishment of many biofuel plantations in all regions in Cameroon with no evaluation on food impacts or agricultural system. This policy gives a possibility to biofuel companies to choose Northwest region and Centre region; these regions interact with forest based root crops and tree crops as found in Figure 3.1 (FAO 2009_a) above. Presently, south region and littoral region are taking the next step. MINADER does not have any data on biofuel production and no present policy concerning interaction with food production. This ministry is also in charge of giving authorizations to import some new seeds or plants; but in Mankim and Kumbo, many *J. curcas* seeds have been brought from Togo, Ghana and India without permission or control. Coupled with no GMOs policy as highlighted by the program director, I think that the risk of GMOs introduction in food product system is very high. The risk is higher because MINADER does not have particular GMOs policy. As highlighted by Bernard Njonga (president of Cameroonians Association of the protection of Interest of consumers), it was also confirmed in MINADER through the director of projects and programmes that their budget is around 3% of the total budget of Cameroon. It is then logical to understand why the markets of biofuel that will control the production and future plans do not exist today. In order to put in place policies, specialists and financial means are needed. No one cares about the future of biofuel or its impacts. Following the impacts on rural poor people, the Ministry of State Property and Land Tenure of Cameroon confirmed that any user of land has to compensate the last owner of that land; this is also confirmed by the Ministry of Justice (1974). This was highlighted last year by M.S.P.L.T. (2008): But nothing has been done in practice in the field of biofuel *J. curcas* feedstock. This has drastically increased the poverty situation in rural area. It was found in the field that around 3 000 hectares of *J. curcas* can only be found in Mankim, Nkoteng and Nguila regions as shown on Figure 4.9, Worldwatch Institut (2006) has shown that the government should provide support for small and medium scales' biofuel production to open an opportunity that they share more in economic gain and reduce poverty. Purchasing from small producers and creating a financial incentive on biofuel trade will develop a reduction of energy demand in rural area. Some international NGOs such as SWISSAID (2008), are not accepting the industrial production of biofuel as I have proven it in this research. The importance of intercropping system is one domain which the agricultural ministry needed such as highlighted by FACT FOUNDATION (2006). According to Prof. Thomas B. Johansson that I interviewed personally in Budapest, former Director of UNDP´s Energy and Atmosphere Programme, "the biofuel policy in Cameroon should be developed by following the Brasilian's case success; in terms of protecting the environment for future need of food production, open the way to small farmers to share more in benefit and that could also promote the rural electrification". We remember that more than 50 % of population is living in rural areas as showed by Madi *et al* (2002). Since the policy is still in reflexion, the most options for MINADER are in Production of biodiesel based on palm oil (MINADER 2008). The second effect of producing biodiesel based palm oil is to drive the palm oil cost which is important for cooking daily meals by most Cameroonians. This would bring poor people to become poorer because they will lose all their lands (if coupled with the effect of other feedstocks based on industrial

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production). The use of wood as fuel and biofuel has led to multiple reductions of living organism and forest destruction (UNDP *et al.* 2000) in case of no planning or policy.

Industrial waste from biomass is also a good resource in its form, as appropriate: hull of cotton, rice husks, bagasse, coffee hull, fiber, palm kernel and wood waste. These primary sources have a good potential in Cameroon, Gabon, in CEMAC and Congo Brazzaville due to their favorable conditions to grow either crop or vegetation. Biomass covers more than 90% of household needs and 80% of the total energy consumption (MINADER 2008). As demonstrated by Worldwatch Institut (2006), WTO (World trade organization) has developed some regulation for trade barrier of biofuel from the experience of Brasil to sell to the EU region. But biofuel should be defined as a product. It is very important not to forget this in Cameroonian policy making.

The certification of biofuel will be better to control the impact on food, but this certification policy will not be opposite to some rules in WTO regulations or states (Worldwatch Institue 2006); if not we will drive towards more forest destruction (which will reduce the agricultural production in the short run) and farmers lands reduction. That is why certification would presumably restrict the harvesting possibility of *J. curcas* fruits and branches for wood while WTO encourages sale regardless of environmental conditions. In addition as demonstrated above, the cultivation of *J. curcas* appears as an excellent adaptation to semi-arid lands and other marginal lands (Jefferson *et al.* 2008): this is an opportunity to cultivate *J. curcas* in Cameroon in a good way instead of bringing problems.

On the following Figure 4.17, it is demonstrated that *J. curcas* can grow in tropical climates conditions with some fertility level; this was even demonstrated in the villager's

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farm land in Kumbo (Figure 4.6, figure 4.8). The North Cameroon is a whole savanna in majority (Figure 4.17). The Far North lands suffer from dessert arrival from Chad through Lake Chad which is reducing significantly in volume. During the last summit of UN nation, the head of state of Cameroon and many other NGOs mentioned that the area of Lake Chad reduces from 26000 km^2 to 25000 Km^2 in 50 years. Due to dissatisfaction with the desertification in N'Djamena, the ministry of environment bans the use of coal and trees (*Eucaliptus* sp) as household fuel (Obs Nouvel 2009). In northern Cameroon, the same method is still in experimentation due to the desertification and the high price of charcoal for fuel that derives from scarcity (Maddi 2007).

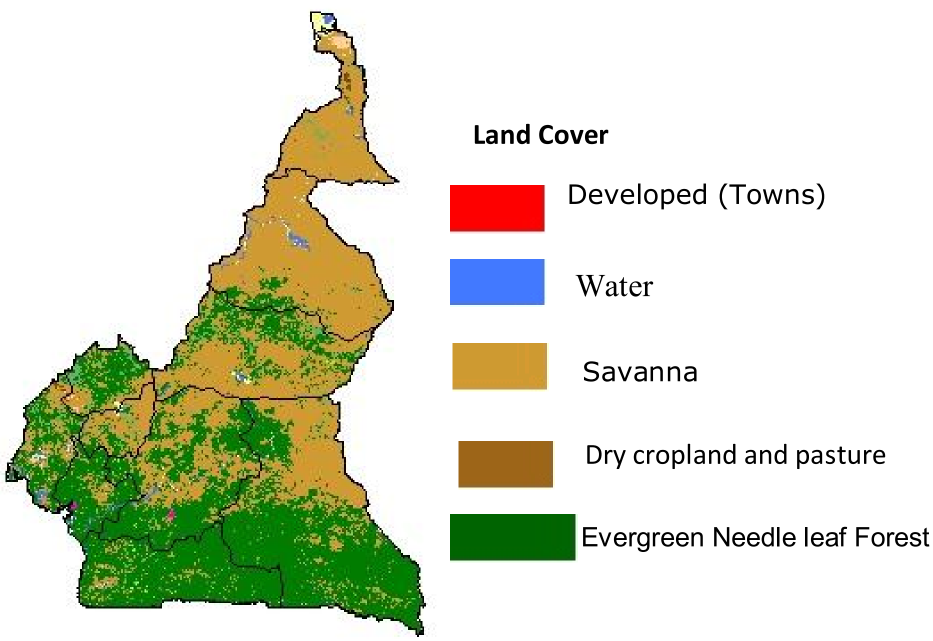

Figure 4.17: Land cover in Cameroon (Adapted from FAO 2009a).

In addition, MINADER should be able to include the *J. curcas* issues in their programme to avoid the negative interaction with agricultural lands and man power. A market for

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biofuel is a regulator for good control of production. Allowing farmers to share more in *J. curcas* production system will reduce the poverty in rural areas. The delimitation of the areas (in the North Cameroon) that can be used for biofuel feedstock cultivation should be done by both MINADER, Ministry of Housing and Land Tenure and be included in Cameroonian's government policy. Any *J. curcas* producer should compensate the land owner that is usually the poorest population. Accepting experimentation on *J. curcas* varieties from other countries (India, Togo, and Ghana) without any permission will increase the risk of GMOs in Cameroon and impact on agricultural production loss.

Deforestation, water table consumption, land use or land reclamation all have impacts on food production or food crisis; this was also highlighted by Mulugetta (2009). The most important issue here is that those factors are closer to the same area of environmental sciences. But in Africa especially in Cameroon, environmental policy or management is done by a broad range of stakeholders or decision makers. This means that policy should be done through contributions and combining all driving forces of biofuel in food crisis and putting together all stakeholders (such as farmers, decision makers, politicians, land owners, traders, investors, NGOs) in the process.

This needs a new thinking framework amongst stakeholders that is highlighted on the following figure 4.18.

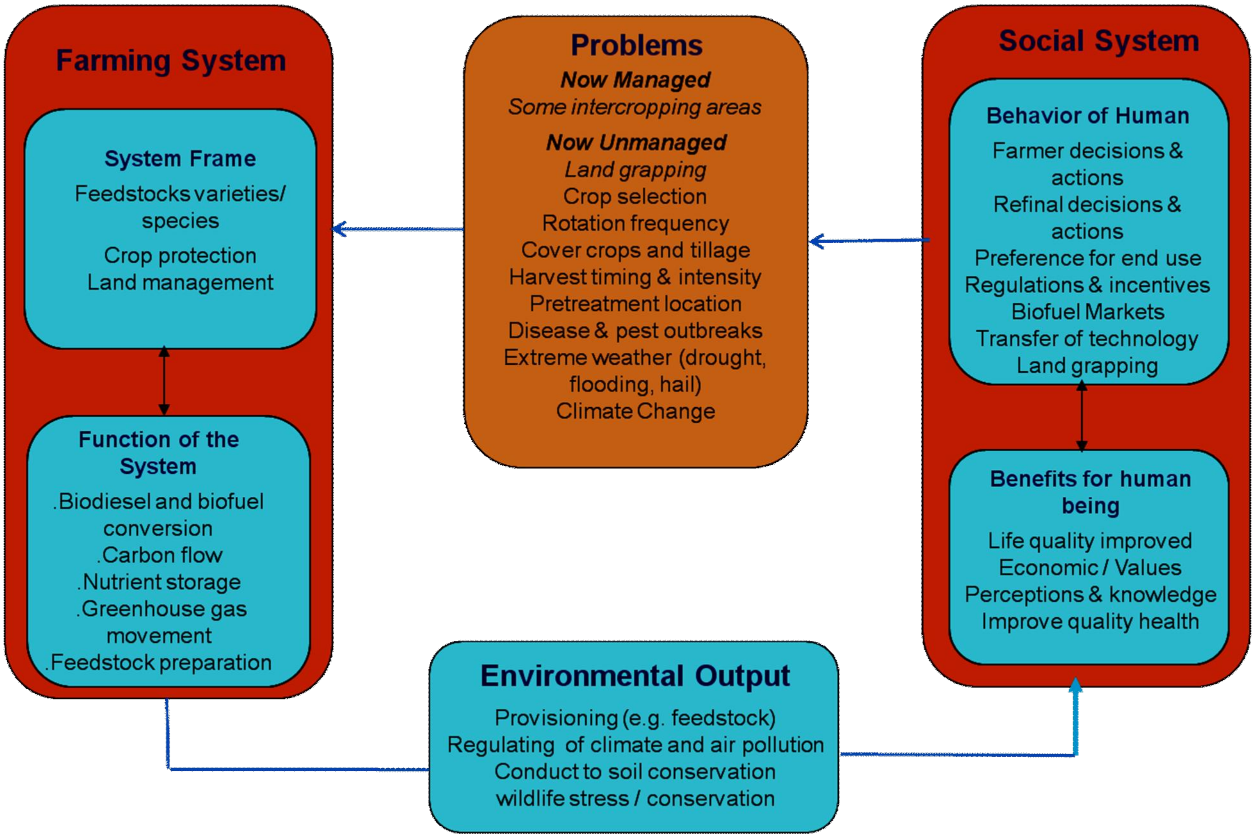

Figure 4.18: A new framework of Eco-sociological thinking of biofuel system for Cameroon.

According to Houghton and White (2009) the traditional framework thinking for biofuel includes farming system, problems and Environmental output. It is how actually investors think in Cameroon. But the need of new system of thinking is very important to mitigate any impact on human life. That is why including social system is very important in the thinking framework; where benefits for human being and behaviour of human should be considered enough in the new biofuel thinking in Cameroon and in the whole Africa too.

The scale model of biofuel production is an important issue to take into account in Cameroon. The following figure 4.19 shows the assessment of different systems in Cameroon.

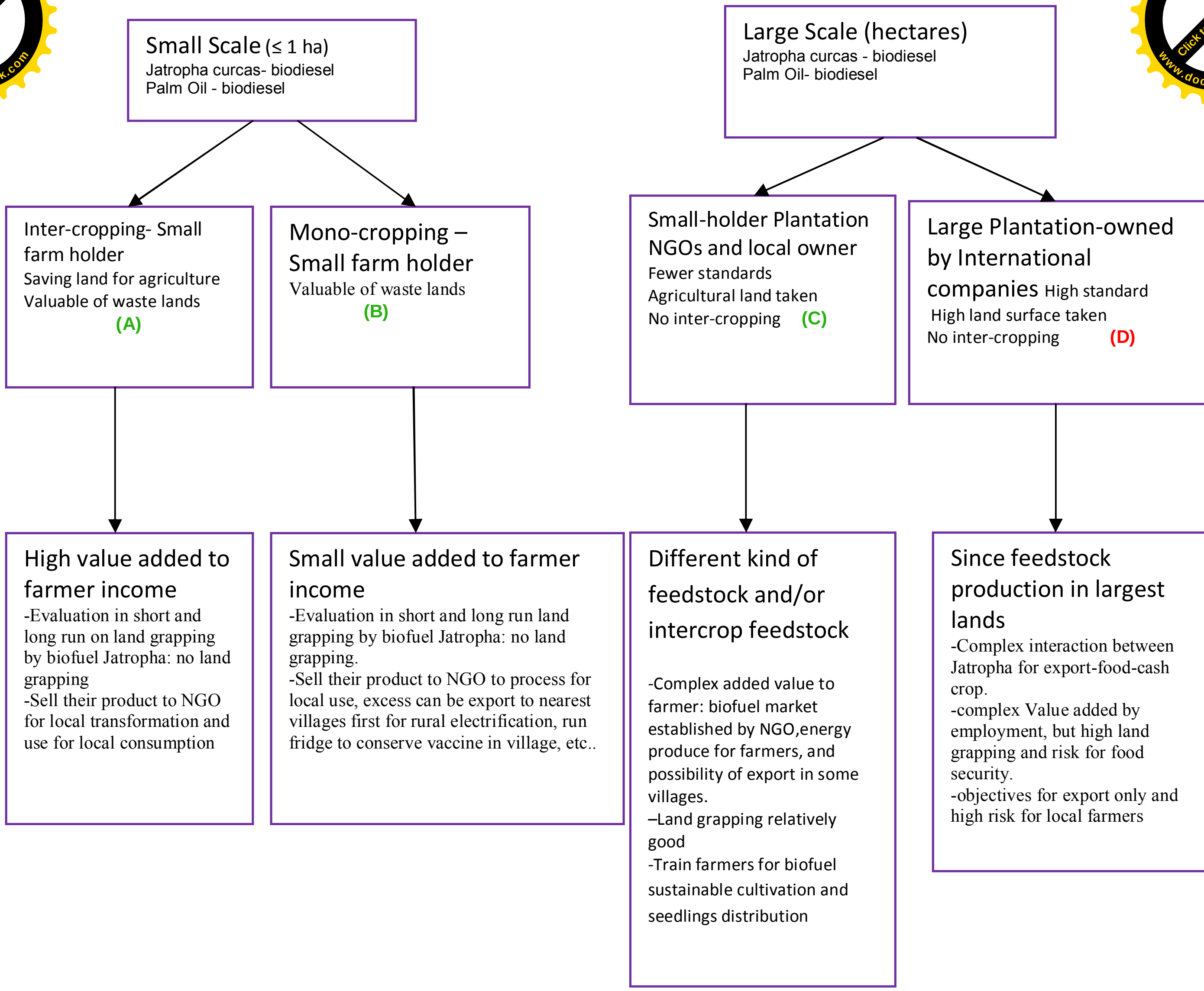

Figure 4.19: Biofuel scales matter and development options in Cameroon

After this assessment on figure 4.19, it is clear that the biofuel policy should take into account the scale. It is found on the figure that assessing small scale in each region by using the new framework of biofuel thinking for Cameroon in figure 4.18 is very important. In general, small scale helps the majority of the population (farmers) to have more shares in the biofuel system. This means that (A) and (B) are well coming for biofuel production (figure 4.19). In large scale system, the less complicated option is (C) option. In fact the complicated system (D) that has more impacts can be useful in Cameroon as well, depending on the region. The desertification in Far North region of

Cameroon and there are some localities with little population. Then the application of (D) will be more helpful and suitable to fight against the increasing desertification from Chad. In some region, combining small scale and large scale should be better: for example (C) and (A) are combining at Kumbo region and actually it works more or less well for farmers.

The impact of the introduction of large scale second generation feedstock in agricultural system has perturbated especially small scale agricultural system: this has driven more manpower to biofuel sector and has reduced their fertile land use. ‘’ The cultivation of biofuel helps us, and more other people because we give more lands to biofuel producers, and they give some kilograms of rice to villagers’’; this was highlighted in the field research by a Bankeng village chief in Nkoteng. This demonstrates how biofuel producers help them never to prepare for long term food security, by giving them small kilograms of rice and taking away their lands instead of helping them to help themselves after. The introduction of *J. curcas* has been done unconsciously by some farmers (figure 4.20) by replacing their fences with *J. curcas*. This is beneficial to them because no animal can consume Jatropaha’s plant compared to other plants that will be replaced due to consumption by their animals. This system helps farmers to provide seeds to those who are in need, and gain a surplus; this system helps to provide more seeds in tropical grassland region (Kumbo). This system is profitable to Mali too where Jatropha is planted in small hedges and the reported productivity is from 0.8 to 1.0 kg of seed (for making) biodiesel per metre of live fence. This equivalence is between 2.5 and 3.5 t/ha/y (Openshaw 2000).

Figure 4.20: Farmer that has used *J. curcas* for animal fence (Nkoteng)[6]_

This means that the development of biofuel feedstock cultivation can have advantages to farmers especially if farmers themselves are managers. For instance, farmer on figure 4.20 above can sell seeds for revenue, possibility to harvest *J. curcas* dead branches (Openshaw 2000) each year for household fuel and make this sustainable fence (long term durability because of no consumption by animal).

I found out that, the man power in Nkoteng biofuel farms is about from 90% and ranges between 21-40 years old; these ages are the driving forces for agricultural production. If nothing is done, all these forces will help to cultivate biofuel feedstocks instead of food.

All these above need that the government should rely on new biofuel thinking in any locality.

[6] Farmer in front of his Jatropha's fence, in his back yard. He has refused to show his face in public for political reasons.

CHAPTER V: CONCLUSION AND RECOMMANDATIONS

V-1 CONCLUSION

''Cameroon is an African in miniature'' as the director of project and programme in MINADER highlighted during our discussion. This means that Cameroon has many agricultural potential found in the whole of Africa through their climatic diversity. But more high percentage of cereals demand are imported into Cameroon which is more than 90% of rice in 2008. Only 3% of national budget is allowed for national agricultural production or for MINADER (office expenses in MINADER plus projects).

In MINADER, nobody knows the relationship between biofuel feedstock impacts (especially *J. curcas*) on agricultural system in rural areas or in Cameroon as a whole.

NGOs and other voluntary farmers have started a new interesting system of small scale *J. curcas* production where farmers share more in the system: they will be able to harvest and sell seeds from bushes, cultivated by intercropping, harvesting and selling, buying oil from small scale producer for end use in the house, using waste for manure). In fact this system works in the Northwest of Cameroon. This also conserves the land very well before 15 years and can conserve the soils for 50 years.

On the other hand, we find a large scale production of *J. curcas* in the Centre regions of Cameroon. This system is very efficient to drive all the fertile land and man power in any village that is possible to find poorest people. Agroil and Venture Energy Ltd are cultivating 300 hectares of *J. curcas* (at Mankim, Nguila, Nkoteng). If concentrating on Nkoteng's, it was found that all this land was owned by farmers. No compensation was made for farmers and for their crops. The inter-space for *J. curcas* is around 8 m in small scale (local utilization of end product) and above 10 m in large scale system (exclusively for export) to use lands (because no intercropping). Farmers in Nkoteng have now as obligation to clear the forest for lands to survive.

The agricultural data production in Nkoteng shows the direct impacts of *J. curcas* on food crisis in Nkoteng region.

The production cost of 1 ton of *J. curcas* is about 460 Euro in large scale system. A kilogram cost 0.46 Euro, only 22% of a kilogram of sunflower feedstock. The price in small scale system is more profitable at present, due to the benefit from energies' crops and energy for other crops. In the CEMAC region, there is no issue for biofuel sector, no regulation. The African Union just tried to set out a discussion for that matter. There is confusion on biofuel product definition itself in WTO.

V-2 RECOMMANDATIONS

V-2-1 Recommandation to the government of Cameroon

-The cultivation of *J. curcas* in large scale is very dangerous for the agricultural system in the Centre region or in the whole tropical rain forest zones. It would be advisable not to allow the large scale production in the region if I coupled the effect of climate change. But, it is still possible and clear that cultivation of these plants in Northern Cameroon will be very beneficial to create the shade for plant cultivation, conserve water and protect the environment to ensure the next generation of food availability (avoiding climate change that is linking to agricultural productivity in the Northern region around Lake Chad).

It should be good to apply a special tax on each square meters of land use for large scale biofuel in tropical rain forest and put no tax on dry savanna land in Northern

Cameroon. This will drive investors to those marginal lands and it will be beneficial for environment, land use and food preservation.

-The small scale production of *J. curcas* should be supported and included in the agricultural system, to allow all technicians of MINADER in any locality to control the impacts or save data for the system.

-The amelioration of seeds quality by breeding should be a priority. Because the seeds used in small scale or large scale that can succeed well are local ones at present, from the bushes and forest. It should be better that, the government designs a breeding seeds programme and let farmers to get involved which will also be beneficial to other crops as well.

-MINADER and other government should select the land that can be used for biofuels in the whole country based on land reclamation pressure (presence of forest, density of population, desertification advancement and fertile lands). Small scale should be well organized with good development of different end use in agricultural mechanization as in Germany.

-MINADER and CEMAC should understand that, there should not be a dissociation or separation between agricultural system and biofuel system as the director of programme and project in that ministry highlighted.

-Introducing the new framework of biofuel thinking is an important issue in building capacity; this should consider all stakeholders that can have an interaction with biofuel sector.

-An introduction of Cameroonian's certification should be a challenge for biofuel control and establishment of a control market for biofuel.

V-2-2 Recommendation for CEMAC

-CEMAC should take into their agricultural policy, the issue of biofuel regulation or market trade. Since there is a communal agricultural overview in CEMAC, the introduction of biofuel combined to GMOs agreement is very necessary. Putting in place a GMOs agreement is very important for the community because every biofuel feedstock and agricultural plant could not be maintained by absence of policy on GMOs manipulation or trade control.

-Helping to harmonize the policy in those six states in CEMAC by training technicians for biofuel issues and the interaction with the agricultural system should be encouraged.

-The introduction of *J. curcas* as an important plant in the project of Environmental Assembly Deputies of the six countries which constitutes CEMAC is very important. Animals will not destroy the *J. curcas* as usual as with other plants use in reforestation projects in Northern Cameroon, Chad and Central Africa Republic. It is possible to use some dead branches of *J. curcas* as fuelwood, use fruit for biofuel which are transformed locally, use waste or hull from oil extraction as manure or fuel wood again.

-The research development in the domain of biofuel should be encouraged and one good system for vulgarization of the result will help to find out many problems and solutions in biofuel feedstock linked to agricultural issues or poverty alleviation.

V-2-3 Recommendation for NGOs

-The development of a production system of *J. curcas* in a locality should be based on small scale production. The intercropping is good but needs to increase the inter-spacing for around 15 m; this is to avoid the total land cover useful for seasonal crops such as cereals.

-The distribution of seedlings to population should be done by using MINADER technicians, who are supposed to know the problems, available land input and performance of each farmers group as found in Himalaian Institute in Kumbo.

-The NGOs should avoid large scale cultivation without intercropping. They can easily afford to run a project and the good example will direct the rest of stakeholder how to practise in the system.

-NGOs should not allow intercropping of *J. curcas* with *Manihot esculenta* (cassava). This should not happen because Cassava and *J. curcas* are both in the same Euphorbia family and one (Jatropha) can be the host of diseases for others (Cassava) such as *Phytophtora Spp, Fusarium Spp, Cercospora Spp* and *Lepidoptera Spp.*

- *J. curcas* will become a promising crop if the seed selection is done by farmers and manual or engine processing is done by a group of farmers. If not farmers will fall in the same trap of coffee and cocoa when the price drop drastically some years ago and farmers could not keep or process their products and use themselves. That is why the local use should be encouraged for rural electrification.

V-2-4 Recommendation for Universities and research centre in Cameroon

- The researchers should focus on second generation feedstock research instead of focusing on first generation feedstock such as palm oil in Cameroon. Any researcher should understand that developing the use of palm oil for biofuel (as is a case in university of Douala, Dschang and Yaounde) will cause more direct problems on food availability, land reclamation, the forest destruction as in Indonesia compared to *J. curcas* aptitude.

-A research on small scale processing for poor farmers will help to reduce energy demand in villages. Depending on local NGOs that will offer the machines for processing (by importing in Cameroon) in the future to farmers after production is dangerous. If the farmers do not have another alternative, they will not have the choice to sell their *J. curcas* fruits to NGOs (at any price: this happened with coffee in the past), if no local ways to get machine is existing. The affair of simple corruption is liable to arise in that situation.

-It should be better to stop research on palm oil for biodiesel to destroy agricultural system and increase food crisis. This is very important in grass land where people usually cook some meal called "Eru" that needs at least one liter of palm oil each time the meal is been cooked. If the price rises due to fuelling cars, they will not afford to buy this oil.

V-2-5 Recommendation for Agroil and Venture Energy Ltd of Italy in Cameroon

-Taking into consideration market as first instead of the human being food is not humanitarian. Poorest population in Mankim, Nkoteng and Nguila needs to increase their living style or have the right to human basic needs (food). Any human being expropriated from his land should have compensation according to the Cameroonian law.

-It would be better to tell the truth to the rural population, instead of telling them that after processing, *J. curcas* oil will be used by them: but the map shows the full exportation intention of all products of Agroil and Venture Energy Ltd. This will probably cause social problems in those areas as it happened in February 2008 in Djombe (Littoral region of Cameroon) for banana plantation (villagers of Djombe cleared more than 20 hectares of bananas during food protest period because they thought that land benefited only the banana companies).

-Recognizing that intercropping *J. curcas* is very important in terms of limiting the erosion by the methods of multiple cropping. This will help confirm that we just ‘’borrow land from our future generations’’.

-Any biofuel company needs to pay the salary of their employees. Remember that the basic salary in Cameroon is 40 Euro instead of 15-20 Euros that companies promised to workers (villagers in Nkoteng) and do not even pay for the last 6 months of work. Since 90% of workers in biofuel farm in Nkoteng village range between 21-40 years, the man power in the village can be continuously drive to biofuel production if any establishment of food crisis remediation policy by government is done.

V-2-6 Recommendation for WTO

-WTO should thing about small scale and poor farmer difficulties in their policy establishment.

-It should be better to distinguish between biofuel itself as food for car and food for human being. There should not be confusion between biofuel feedstock (or biofuel end use product) and other products in the international market. The real definition of biofuel by WTO should revise well.

V-3 GENERAL CONCLUSION

February 2008, protest over food crisis was a result of a significant and permanent contribution of biofuel production on agricultural system. The large scale production of biofuel cultivation is responsible for boosting food crisis. The food crisis was common in CEMAC zone (6 countries and neighbors) because of CEMAC agricultural market crash in Cameroon contributing by biofuel system.

After Maputo Protocol that was signed many years ago and that obliged African countries to increase their agricultural budget of investment by 10% of their national budgets, it is still up to 3 % in Cameroon and many other countries in Africa where hunger gave rise to demonstration (in 2008). An application of Maputo Protocol by all countries in Africa should be a step to diminish food crisis. Many countries including Cameroon found a way to import food instead of producing food with all the risk of international variation cost and demand changed in other part of the world such as the Asia region (some people changed their diet for proteins which needed more cereal for animal consumption to make it).

J. curcas can be a promising crop in Cameroon and Africa if the new thinking framework of biofuel system is integrated amongst activities of production. The small scale system of production is profitable in term of rural electrification and poverty alleviation. The destruction of forest reserve is direct evidence from large scale production of biofuel. The large scale cultivation of *J. curcas* also has direct impacts on food shortages at present. The use of palm oil for biofuel production drove the cost of this food in the tropical regions of Africa, where many farmers cannot cook their meals without oil. In the CEMAC region, there is no issue for biofuel sector, no regulation. The African Union just tried to set out a discussion for that matter. There is confusion on biofuel product definition itself in WTO that will increase the weakness if the consideration is not done on the biofuel policy.

The development of agricultural sector based on cereals is very strategic because of its importance in nutrition. And cereal plant can be harvested two times per year compared to other crops and it is also one of the principal animal foods.

A cost of large scale biofuel production should be internalized in the biofuel certification process to avoid the weakness in another certification field. Due to the fact that some biofuel feedstocks production are cheaper in Central Africa and other developing countries as compared to western countries, this is causing biofuel funders from western countries to struggle for agricultural lands in Cameroon in particular and Africa and other developing countries in general. This has been stimulated by free market agreements that were signed between European Union and most of African and Caribbean Pacific states in 2007, which took place one year before the food crisis uprising. The new thinking of biofuel production and consideration of environmentalist and our future generation will bring all stakeholders into a sustainable biofuel production and consumption.

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ANNEXE I : QUESTIONNAIRE FORM

Theme 1: Identification

Name of investigating officer:…………………….. Form N°………. Date…..

Name and surname of the person to be investigated:…………………..

Age : 0-20 years old ☐ 21-40 years ☐ 41-60 years ☐ 61 years and more ☐

Sex : Male: ☐ Female: ☐

Site:………………………

1-1 Educational Level

a) No school level : ☐
b) Primary school ☐
c) University ☐

1-2 Principal Activity: Fisherman ☐ Village Chef ☐ Buisness man ☐

Farmer ☐ Minister/secretary ☐ Other…………………………………… ☐

1. Theme 2: Perceptions of the problem

2-1Is biofuel according for you useful and is been gradually introduced into the agricultural system of Cameroon?

1) Yes ☐ No ☐
2) Is biofuel creating employment? Yes ☐ No ☐
3) Do you feel that biofuel feedstock is helping us in our agricultural systems: Yes ☐ NO ☐

2-2 Are biofuel companies occupying your land by force? Yes ☐ NO ☐

2-3 Can you give the origin of second generation biofuel feedstock (Jatropha, ..)?

1) From government: Yes ☐ No ☐
2) Don't know: Yes ☐ No ☐
3) From other farmers: Yes ☐ No ☐
4) From abroad: Yes ☐ No ☐

2-4 Age of plantation

1) About (1 to 3 years): Yes ☐ No ☐

2) Since (4 to 10 years): Yes ☐ No ☐

3) Since (10 or +): Yes ☐ No ☐

2-5 Since they started cultivating these feedstocks, it has:

a) Increase ☐ ....%

b) Decrease ☐ ....%

c) Stable ☐ ....%

Theme 3: Behaviours

3-1 Culture.

1- Does biofuel modify our culture? Yes ☐ No ☐

2- Does biofuel reduce our water availability? Yes ☐ No ☐

3-2 Are you afraid for a new decrease in food?

1-Yes ☐

2-No ☐

....

1.1 Theme 4 : Agriculture policy

4-1 Do you cultivate biofuel feedstock/jatropha/palm oil?

a) Yes ☐ b) No ☐

4-2 Are you rearing fowls?

a) Yes ☐ b) No ☐

4-3 How is the reduction of your capacity of production of fowls due to lack of maize?

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a) Yes ☐ Number................. Tonne ; Maize .... b) No ☐

4-4 Do you used fertiliser for farming?

a) Yes ☐ b) No ☐ c) ……………………

4-5 What it the percentage of the ministry of agriculture budget in the whole national budget?

a)...........% b)......... ....Euro/FCFA

4-6 What percentage is allocated for fertilizers?

a)..................% b).....................EURO/FCFA

c) Types of fertilizer: 20-10-10☐ others..............................

4-5 In which period these fertilizers are distributing to farmers?

a) 2002: No ☐ Yes ☐ Beginning of the month........................

b) 2003: NO ☐ Yes ☐ Beginning of the month........................

c) 2004: No ☐ yes ☐ Beginning of the month........................

d) 2005: No ☐ Yes ☐ Beginning of the month........................

e) 2006: No ☐ Yes ☐ Beginning of the month........................

f) 2007: No ☐ Yes ☐ Beginning of the month........................

e) 2008: No ☐ Yes ☐ Beginning of the month........................

Theme 5 : Policy of Biofuel

5-1- Areas Allocated for different biofuel feedstock.

a)How many percentages or Ha of lands are allocated per province? (please tick and put the percentage).

North☐ ....Far North☐........ Adamaoua☐ ....Centre☐.........Ouest☐ ....

North West☐.... West☐..... East☐....... Littoral☐ .... South☐ ....

b)Have you been in the field? Yes ☐. NO ☐

c) Do large scale biofuel companies have obligations regarding farmers? Yes☐ NO ☐

d) What is the future plan for biofuel feedstock's production areas?

Increase the surface for biofuel : Yes ☐ No ☐

5-2- Biofuel feedstock Utilisation.

a) There is an objective of local transformation? Yes☐ No☐ Within national transformation ☐

b) For exportation. Yes ☐ Tonnes.............. NO ☐

b) Are taxes introduced by government for biofuel feedstock producer?

Yes ☐ Which one?..

NO ☐ Why?...

c) Is there any type of compensation for farmers due to taking their land?

Yes☐ How much?..EURO/FCFA

No ☐ Why..

d) Is there any set of feedstock biofuel accepted by the rule for farming?

Yes: ☐ d0...d1...

d2...d3...

No ☐

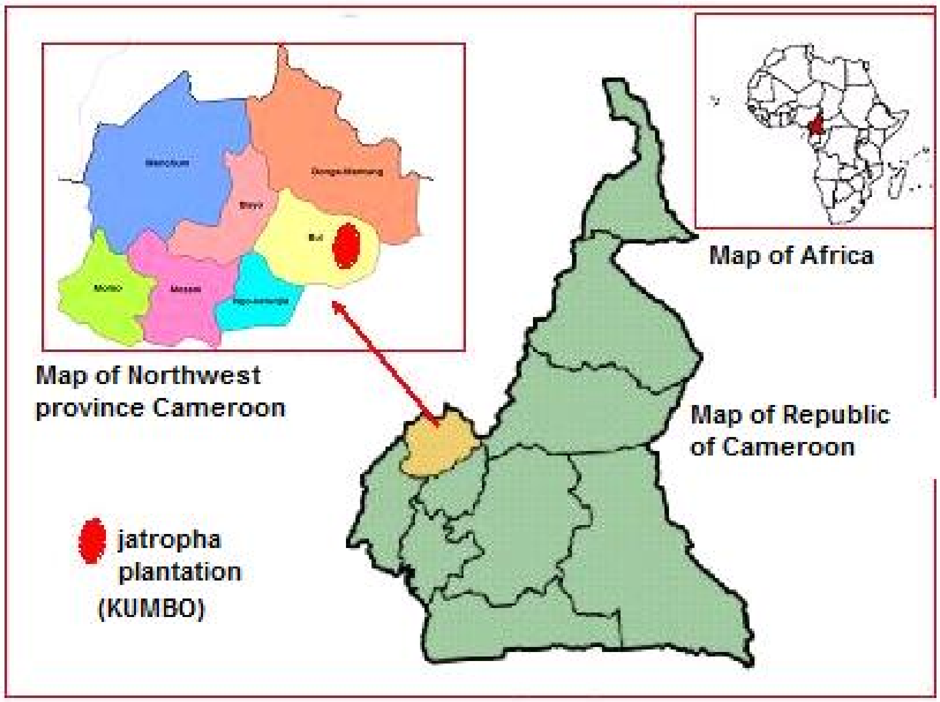
e)Does the introduction of second generation did not have impact on food.

Yes ☐ No ☐

ANNEXE II: SOME PICTURES AND MAPS

1-This picture shows the accident that the author had on road from Nkoteng centre to Agroil Plantation; because of raining season, only this type of forester truck can pass along this road: this caused me one night and one day to wait for new occasional forester's truck.

2- Seedlings sites of Himalaian Institute in Kumbo



3-Localisation of small scale cultivation biofuel (Jatropha) in Cameroon (Adapted from Greenery Association office; Kumbo)

4-Overview of small scale lands in rural area of Northwest Cameroon (Kumbo): Proof by different owner with different high of plants on around 50 m^2

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4-Greenery Association seedlings nursery in Kumbo (Picture from Kumbo site).

5. This is one tree of Jatropha in Greenery Association system (can reach 7m high and more than 7 m canopy; picture from Greenery Association field site and office in Kumbo).

6- Interview with His Highness Bogo Bernard chief of Bankeng village in his palace at Bankeng near Agroil plantation.

7- The field guide equipped with the moto bike, who accompanied the author to some localities that access with cars was impossible in raining season (Jun-November).

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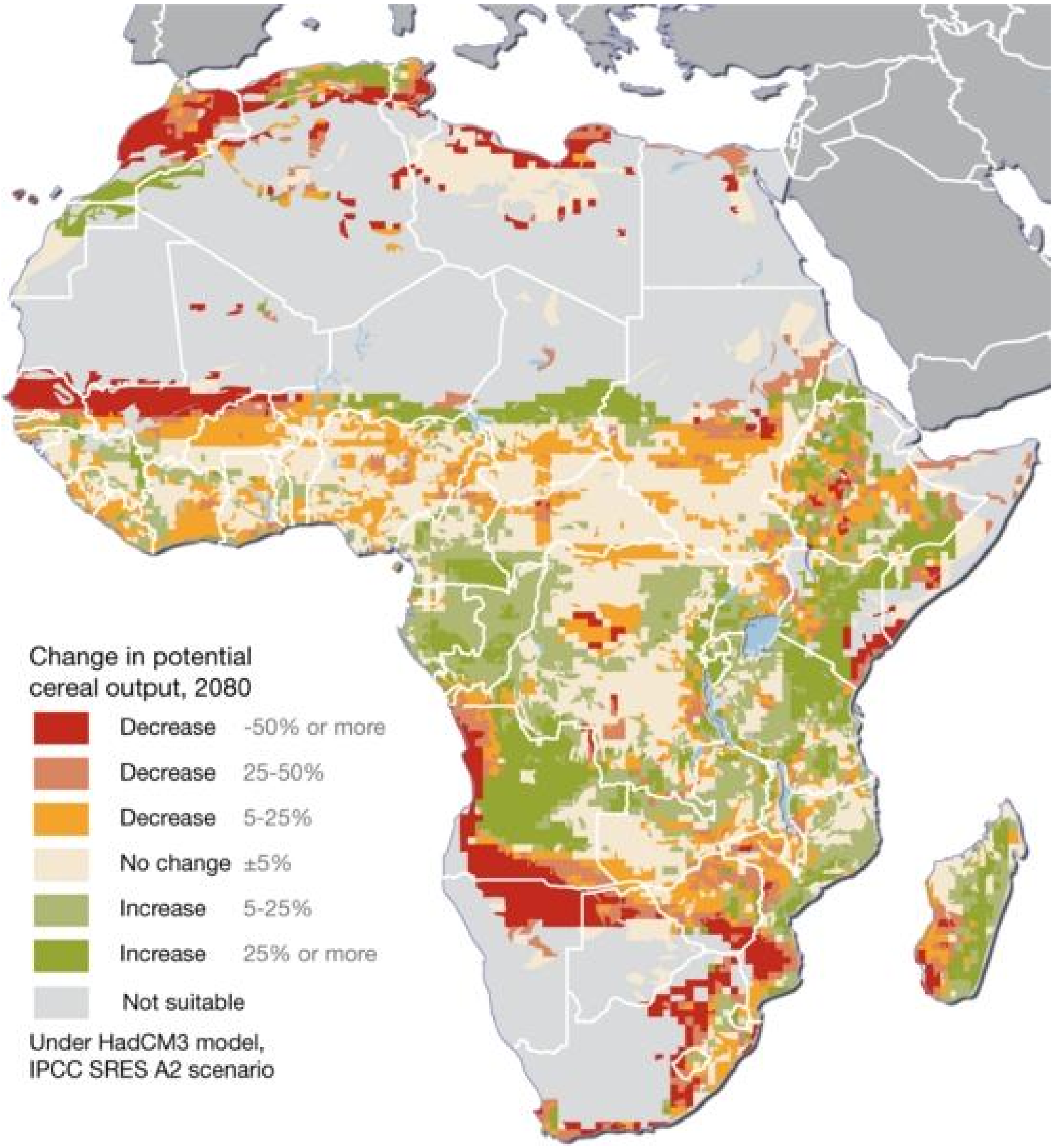
Change in cereal scenario including Cameroon regions (UNEP 2009)



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